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Essentials of Geography

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Essentials of Geography

By

OTIS W. FREEMAN

Professor of Geography
Eastern Washington College of Education

and

H. F. RAUP

Professor of Geography and Head of the Department
of Geography and Geology
Kent State University

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ESSENTIALS OF GEOGRAPHY

Preface

Geography deals with conditions on the earth that are related to both the physical and the social sciences. The facts concerning the climate, relief, soil, minerals, forests, oceans, and other factors of the natural environment throughout the world and on the different continents are needed for an understanding of the relationship of these factors to the activities and occupations of man. Furthermore, geography provides a better understanding of foreign peoples and their special problems and increases the interest in and enjoyment of literature, history, and other subjects. The value of a geography course to a student depends to a considerable degree on the application of his knowledge in activities after he leaves college.

Knowledge of the development of landscapes adds to one's pleasure while traveling and reading. Practice in observation, the description and interpretation of landscapes, and other geographic abilities is a fundamental requirement for the science of geography. Study in the field and laboratory; construction and interpretation of maps, graphs, and statistics; logical compilation of information from nontextbook sources; and learning the sources of other geographic material should supplement any course in geography. Among values that should be emphasized in geography are the technique of reading maps, the collection of needed data from other sources, and the formulation of generalizations and conclusions from this material.

Concepts of the interpretation of the field of geography have been subject to change. During the Age of Discovery, which began toward the end of the Middle Ages, geography was concerned with the collection of facts about the earth and the construction of maps. Near the close of the nineteenth century, it developed as the concept of the interrelationship between man and the earth. This relationship gives a point of view to geography that differentiates it from other sciences.

Geography is a dynamic science because man's relationships to nature are constantly changing. Man affects the natural environment by such activities as the clearing of forests and the drainage of swamps. He also develops new ways to use known resources by such improvements in farming practices as dry farming or the development of hybrid corn or by such technologic improvements as the extraction of a useful substance from a former waste product.

A geographer needs an open mind, curiosity, and an urge for the discovery of truth. He should become familiar with the techniques of investigation and accustomed to formulating sound conclusions. There is no single method of learning geography; sometimes one system is helpful, whereas a different way of presenting the subject will be more successful in another situation. It is hoped that, when the interest of students is aroused, they will continue their study of geography long after leaving the classroom, because material in the field is abundant and the subject readily lends itself to individual investigation.

"Essentials of Geography" first surveys earth relations, the atmosphere, and the tools of geography. Then follows a description of the climates of the earth and their relation to man and other organic life. Mountains, plains, and oceans receive consideration, as do the minerals, soils, forests, and inland water resources, including the problems of their conservation. After the facts concerning the natural environments of man are discussed, the balance of the text is devoted to the geography of population, cities, agriculture, manufacturing, nations, transportation routes, and

factors affecting man on the various continents.

Considerable space is devoted in the text to descriptions of primitive peoples because their relations to different environments are simpler than those of culturally advanced peoples, who may have modified their environment greatly and who utilize products from distant lands.

Numerous projects and problems, and the questions at the end of each chapter, are included to help to emphasize certain facts and principles of geography. The references are selected from many found useful by the authors and are not intended to serve as comprehensive bibliographies. The authors will welcome suggestions from teachers concerning problems, questions, references, and geographical material that might be added or omitted.

The authors received assistance from many sources in the preparation of the manuscript for "Essentials of Geography." Credit for the use of photographs is given in connection with the illustrations. Certain chapters were checked critically by authorities, notably William C. Pryor of the Soil Conservation Service, and C. W. Mattison and others of the U.S. Forest Service. Help also was given by the U.S. Geological Survey staff members, the U.S. Bureau of Mines, and the U.S. Reclamation Service. The authors are deeply appreciative of the valuable suggestions offered by many of their colleagues in the profession of geography.

OTIS W. FREEMAN
H. F. RAUP

CHENEY, WASH.
KENT, OHIO
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CHAPTER 1: *The Scope and Purposes of Geography*

Introduction

Geographic knowledge has been useful since the first human beings began their struggle for existence. Primitive man needed to know the sources of flint for his weapons, the environments favorable to fish and game, the kinds of edible plants and their location, and the streams and paths followed in his migrations. Early man lived so close to nature that he had to be in adjustment with his environment in order to survive. Early Norse settlers in Greenland, for example, died out apparently because they did not adjust their lives so successfully to the arctic environment as did the Eskimo, who survived in spite of the frigid climate and limited sources of food. Civilized man is also greatly affected by geographic factors. Our food, clothing, shelters, utensils, and machines depend largely upon geography. In part the supplying of these needs depends upon the local environment, materials available, and accumulated skill of the inhabitants, but needed goods may also be brought from distant regions by our modern transportation.

Advances of knowledge help man to overcome natural handicaps, but most human activities are closely related to various geographic factors. It cannot be too strongly emphasized, however, that the relationship between man and nature is a mutual one. Man is affected in many ways by his geographic environment, but he also exerts profound effects upon nature. He drains swamps, irrigates deserts, tunnels through mountains, bridges streams, overcomes outside heat and cold by air conditioning, saves labor by machinery, and imports or develops types of needed plants and animals. Man should study his environment and learn how he can most successfully adjust himself to his natural surroundings or how he can best overcome the natural handicaps of his location.

What Is Geography?

Geography is fundamentally a description of the earth. In practice the science deals with the world, the distribution of things and people on the earth's surface, and the relationship of man to the varied environments and resources. In this text we shall consider geography to be the study of the earth and its relationship to man and his activities. Earth environments are complex and result from the interaction of such different factors and forces as rainfall, sunshine, growing season, location, land and water features, minerals, vegetation, soils, disease, and animal life. It should be remembered, in evaluating the influence of these material factors upon man, that peoples may react differently to similar natural environments because of their culture, experience, natural aptitude, and other human elements. Man also often overcomes handicaps in his environment, and locally he may change some of the geographic conditions. Although it is frequently impossible to state or to recognize all the factors that have combined to produce observed results, they nevertheless exist.

The present landscape in any area settled by man is the net result of the combination of the natural and human factors that have operated therein. Natural physical features have been modified by the cultural activities of man, who has made a great impression on the original landscape with his roads, fences, houses, tilled soil, mines, mills, and many other works.

Changes in Concepts of Geography. Geography helps explain the location of cities and

industries, the occupance of the land and the evolution and expansion of nations. Originally geography dealt with place locations and facts—boundaries, physical features, climate, extent, trade and statistical information about continents, nations, states, and cities. Progress in geography during the last half century has been rapid, and the materials and matter now included in the subject have been greatly broadened. Today many fields are drawn upon for their geographical implications, and knowledge has expanded concerning the factors that affect man's activities. Geography has become an inclusive and acquisitive science.

In ancient times men described and mapped the part of the world known to them and then guessed at the rest. Through the centuries navigators and land explorers have discovered and made known most of the world, until today only parts of Antarctica and a section of the Arctic Ocean are still marked unknown. With increased knowledge about the peoples and their environment geographers included in the subject the relationship of man to the climate, relief features, soils, minerals, oceans, and other factors and resources of the world as well as the facts concerning these things.

Location

The location of a people and country is of paramount importance. Location may be studied with reference to latitude and longitude; situation with respect to land masses and water bodies; location as it is related to earth features like mountain passes, lakes, harbors, and river valleys; natural resources such as coal, iron ore, and forests; sites concerned with natural and with man-built transportation routes; and the effect of neighboring nations with different cultures, ideas, and development.

Position on the Earth. Latitude, or angular distance from the equator, is the principal factor determining the climate of a place and hence is more important than longitude. If the weather of a given location seems unfavorable for human activities, it is sometimes possible to change one's latitude to provide a more favorable environment. Elderly residents of the northeastern United States find a more pleasing climate by spending their winters in Florida—a more southerly latitude. Englishmen for many years have sought the sun in southern France on the Riviera, in an effort to avoid the unpleasant fogs of London. If someone does not like the weather, it *is* possible to do something about it.

Altitude as well as latitude governs much of our weather and climate, and this is of special importance on those continents—South America and Africa—which "straddle" the equator. The most productive and populated part of tropical Brazil is the southeastern highland near São Paulo. Here the unpleasant features of the tropics may be avoided by moving human activities to the upland areas. The highlands of the interior parts of Nigeria are among the most populated parts of the continent of Africa, though they are situated only 10 degrees of latitude north of the equator.

High latitudes where the sun's rays always reach the earth indirectly offer a meager living for human beings because of their lack of warmth and their snow and storms. They are even more unsatisfactory than the humid tropics for supporting human life. In these far regions, almost all labor must be directed to the preservation of life, and little time or energy remains for the production of goods that are not essential. The Eskimos who live at Barrow, Alaska, must spend most of their time obtaining food by fishing and hunting, for agriculture in the higher latitudes is unsuccessful because of the short growing season. These natives must provide themselves with warm clothing and with fuel to last them through the long winter. They are in no po-

sition to provide themselves or others with more than absolute necessities for living.

Since both low and high latitudes are relatively unfavorable for large numbers of people, and tropical high altitudes are of limited extent, it follows that middle latitudes represent conditions suitable for the activities of most human beings. Here the climate is not too enervating; here it is neither too cold nor too hot, too wet nor too dry, for long periods of time. For this and other reasons those civilizations which evolved in middle latitudes have come to dominate the rest of the world because of their high productive capacity and their energetic and enlightened residents. Europe, the United States, southern Canada, Japan, New Zealand, much of China, and parts of South Africa and Siberia are in the favored mid-latitudes.

The development of modern transportation has permitted some favorable climatic regions to specialize on certain crops and sell them to distant markets, thus providing some flexibility to man's position on the earth. Oranges from California and Florida and bananas from Central America are sold in New York. Coffee from Brazil and jute from India are shipped to San Francisco. Large parts of the semiarid grasslands in the mid-latitudes of North America, Australia, Argentina, and the U.S.S.R. have been plowed and planted to wheat, which is then shipped to foreign markets.

Land and Sea. Location with respect to land areas and oceans is a factor that affects the characteristics of people, cities, and countries. In Norway the land is poor for farming, the coast line is irregular with many harbors, and the ocean swarms with fish. The men become fishermen and sailors, and the economy of the country is directed seaward. The inhabitants of lands with extensive fertile plains in favorable climates are quite satisfied to stay at home and are seldom interested in ocean industries. This is true in central China, most of Russia, and the Middle West in America. Nations such as the United States and France facing on more than one sea or ocean are favored for carrying on foreign commerce, with resulting expansion of their seaports and manufactures. Large islands adjacent to progressive continental locations—England and the European continent, for example—enjoy particularly favorable sites for commercial traffic.

Natural Features. Human geography is much concerned with man's adjustment to the many land and water features. Passes across mountains serve as funnels to concentrate railroads and highways crossing the barrier. Cities naturally grow at the end of an important pass, from which routes diverge to serve a wide territory. This is the case at Chattanooga, Spokane, and El Paso in the United States. Peshawar in Pakistan (Moslem India) and Kabul in Afghanistan guard opposite ends of the Khyber Pass. Narvik, Norway, is the shipping outlet for iron ore brought by rail through a low point in the mountains from Kiruna in northern Sweden. Although Narvik lies north of the Arctic Circle, the coast of Norway is warmed by the Gulf Stream and remains ice-free all winter. The Suez and Panama canals resemble mountain passes in having cities at their ends and divergence of routes from the terminal ports. Cities often develop on low land at the end of a mountain range because of the concentration of routes around the barriers; Atlanta, Georgia, is an example. Routes of travel are also deflected around large lakes and broad swamps, and cities may therefore develop at the junction points. Chicago and Winnipeg represent the effect of lakes. London is located at the head of an estuary whose shores are swampy and difficult to cross.

Accessibility. Any features, either land or water, that cause routes to converge are favorable sites for settlements, and many of the principal cities in the world owe their growth mainly to this factor. Of the numerous possible situations, only a few examples will be given. Among these are (1) at a natural crossroads in a basin (Munich, Paris), (2) confluence of rivers (Pittsburgh), (3) junction of land and river routes (Kansas City or Bel-

grade, Yugoslavia), (4) break from lake to land routes (Buffalo), and (5) especially favorable, a seaport where ocean ships meet river boats and land routes up an important valley (Shanghai; Hamburg; New Orleans; Portland, Oregon; New York; Buenos Aires; Calcutta; and hundreds of others). To be of value for trade and to permit the growth of any considerable city a harbor must have practicable and developed routes inland to a productive hinterland. Fine harbors in Alaska, Norway, and southern Chile are sites of tiny fishing villages or entirely unused because they lack a hinterland.

The Resource Factor. The location and growth of many communities have been favored by occurrences of natural resources. Furthermore, after settlements have once been established, the soil, minerals, and other nearby resources have increased in value. Cheap transportation, as by water, to markets and manufacturing plants also increases the value of many resources. Coal, timber, or fruit available in a thinly peopled locality remote from markets and transportation have limited use and little worth. Thus oil in the Mackenzie Valley is remote from large markets and has small present value, and iron ore in the interior of Labrador will be unworkable until railroads and docks are built and the iron is needed by the steel mills. In contrast, low-grade iron-ore beds near Birmingham, Alabama, and Newcastle, England, are extensively worked because they occur adjacent to coal and markets. Truck gardening is preferably carried on near large cities, while equally good or better land located at a long distance from markets is used for growing wheat or grazing livestock. Natural gas near Pittsburgh and Cleveland is more valuable than gas in Texas and Alberta. In cities the correct location of a store is highly important to the owner, who gladly pays high rent for desirable corners and streets frequented by prospective customers rather than low rent at a place where few people pass. Mills and factories may build in the outskirts of a city or in areas unsuited to residences to secure a cheaper site, if the area has access to railroads and other transport.

The need of the modern world for certain metals has resulted in some settlements in mountains, deserts, and frozen wastes that would be uninhabited without the mineral resources. For example, the mining towns of Leadville and Cripple Creek in Colorado are nearly 2 miles above sea level. Potosí in Bolivia and Cerro de Pasco in Peru are situated at still higher elevations. Butte, Montana, without its rich veins of copper, would be a hamlet supported by a few stockmen. The copper camp of Chuquicamata, Chile, and the gold-mining town of Kalgoorlie, Australia, are in deserts where the miners must pipe water for long distances. Nome, Alaska, and Dawson City, Yukon Territory, are in cold and remote localities that would never have become cities except for the discovery of placer gold. Supplies and workmen for the uranium mines of cold northern Canada are brought in largely by aircraft. The occurrence of tin in the Malay Peninsula and of gold in New Guinea has resulted in settlements in the tropical jungles where otherwise only primitive natives would live.

The Conservation Factor. Man is both a destroyer and a wise builder and user of natural resources. He frequently exhausts the soil by continuous cropping and causes erosion by improper methods of cultivation, yet he also rebuilds the soil and enhances its fertility. He has exterminated some species of wildlife but has improved domestic animals; he destroyed some forests but has expanded some forested areas and introduced and developed many plants. Man has progressed in his conservation of resources and improved in their utilization.

Recreation and Health. Favorable locations for recreation account for development of areas that otherwise may not be advantageous. Beach resorts like Atlantic City or Biarritz, France; Mar del Plata, Argentina; Ostend, Belgium; and Brighton, England,

have been established within a few hours' travel of well-populated regions. In the tropics mountain resorts like Simla and Darjeeling in India and Baguio in the Philippines are almost a necessity for the maintenance of health and energy by peoples of European descent. In the mid-latitudes mountain resorts are used for both summer and winter recreation, as at Sun Valley, Idaho; Lake Tahoe and Yosemite, California; Banff, Canada; Chamonix, France; Zermatt and Innsbruck, Austria. Lake resorts in the forests of the northern United States and Canada have grown with the development of automobile travel. Among numerous health centers founded at springs are Hot Springs, Arkansas; Vichy and Lourdes, France; and Baden, Austria. Colorado Springs, Colorado, and Albuquerque, New Mexico, have capitalized on their climate to attract health seekers. Some winter resorts show a remarkable growth, for example, Miami and Tampa, Florida; Los Angeles and San Diego, California; Phoenix, Arizona; and Nice, France.

Neighbors. The strength, character, and culture of neighbors influence international relationships and the development of peoples. Trade and travel are little impeded by the 2,500-mile boundary between the United States and Canada. Papers, magazines, radio, and streams of visitors flow freely across the line. In contrast the multiplicity of boundaries in central Europe and the Balkans seriously interferes with exchange of goods, services, and ideas, in part because of mutual fears and jealousies. Suspicion of a neighbor's motives is a handicap to the exchange of both products and information. Small states may serve as buffers between powerful states. Examples include Afghanistan between Russia and India, Belgium between France and Germany, and Poland between Germany and Russia before the Second World War.

The situation of a city or country in relation to important regions is often a leading factor affecting its development. England's location off western Europe has been very advantageous, although the development of aircraft has destroyed that country's "splendid isolation." The Netherlands and all of Germany's former neighbors bought largely from her and are much interested in the rebuilding of Germany as a market, a supplier of goods, and a competitor. Most cities are workshops that supply manufactures in exchange for foodstuffs and raw materials and grow in proportion to the development of their trade areas.

Nations that lack seacoasts have an obvious handicap and must keep on good terms with their neighbors through whose territory exports and imports are routed. Czechoslovakia, Austria, Hungary, and Bolivia are countries in this situation. Sometimes nations wage wars for an outlet to the sea; the foreign policy of Russia for several centuries has been largely concerned with obtaining ice-free ports.

Location far from world markets is injurious to trade and rapid development. New Zealand, Chile, and Alaska are in this position. The building of the Suez Canal and the routing of ships through the Mediterranean put South Africa far from the major trade route connecting Europe and Asia. Once Capetown had the advantage of a location on the sailing route to India; now its location on the south tip of Africa is a disadvantage because it is remote and off the steamship routes that run through Suez. In contrast Port Said has benefited. Change from sail to steam vessels caused the islands of Ascension and St. Helena to lose importance as supply stations for vessels sailing from England to the Indies. Certain islands that once were thought hardly worth having have assumed strategic value through the development of aircraft. If flights are made across the arctic, the northern tundras in Alaska and Canada may become important. Favorable conditions for trade and defense may thus be changed by new inventions and works wrought by man. The cutting of canals and tunneling of mountains are examples that have changed the relative importance of cities.

Environment and Occupations

The effect of environment on human activities is well shown by such primary occupations of man as farming, herding, forestry, mining, and fishing.

Agriculture. Factors that influence farming include quality of soil, slope and drainage of the land, amount and distribution of rainfall, temperature and length of the growing season, available seeds and plants, domestic animals, presence of insect pests and plant diseases, and sometimes water for irrigation. Skill, energy, and ability to reason and learn from experience are important human factors. If farming is to succeed commercially, costs, prices, freight rates, and transportation to markets should be favorable.

If climatic conditions are satisfactory, yields of crops are in proportion to the soil fertility and care used by the farmer. Dense populations of 800 to over 1,000 persons per square mile supported by agriculture occur in India, China, and Japan on fertile plains in humid regions having a long growing season. Irrigated valleys in deserts may also support great density of population, as in the Nile flood plain and delta in Egypt. Tropical lowlands seldom support large numbers of people; but the mountainous island of Java, almost under the equator, has singularly fertile soil and feeds nearly 40 million persons besides exporting large quantities of plant products. Farms of the Orient are small, hand methods are in vogue, and most of the food crops are of necessity consumed locally by the farm families. In contrast to this subsistence agriculture are the large farms operated by machine methods in the Middle Western Corn Belt and the wheat farms on the Great Plains of the United States. Here one farmer may produce enough grain or meat to feed thousands of people, and in a good year a farmer with 1,000 acres in wheat may sell 30,000 bushels—an amount consumed annually by a city of 5,000 inhabitants. In a similar way some orchardists grow enough apples or other fruit to supply the demand of an entire city. In general, regions with fertile soil have higher living standards and have made greater contributions to progress than areas handicapped by poor land. The people living in tropical rain forests, as in central Africa, those farming in remote places, and those who struggle for a living from tiny farms in countries like India and China are subsistence farmers. The largest occupational group on earth, which includes nearly half of the world's population, are these self-sufficient farmers.

Herding. Herding may be an occupation for primitive peoples who wander with their animals over vast grazing grounds remote from civilization, or it may be a highly organized and specialized industry such as sheep raising in Australia or cattle ranches on the Argentine Pampas. In general the herdsman utilizes lands unfit for farming. Mountain meadows, undrained swamps, desert browse, and the grass of semiarid hills and plains can all supply feed for domestic animals. Even the arctic tundras furnish the food required by reindeer. Usually only sparse grazing is available to the herds on the types of land mentioned. The herds must roam widely for feed, and the human population is very limited. Much of the grazing land of the world supports less than one human inhabitant per square mile. Transportation is less important to the herder than to the farmer, because animals can carry themselves long distances to markets and because some animal products such as wool, hides, and tallow are valuable enough to stand costs for transport that are prohibitive for cheap grains like wheat or rice. The culture of tribes that make a living by herding is generally simpler than that of neighboring agricultural peoples.

Forestry. The exploitation of forest resources is today largely associated with our complex modern civilization. Only in the most remote forested regions do we find widely scattered natives who eke out a living by hunting, trapping furs, fishing, gathering wild products, and sometimes doing a little

gardening. Examples of this type of existence are the Chippewa Indians of Canada, some Indians in tropical South America, and some natives in Siberian forests.

The lumberman uses machines to cut, saw, and carry wood to markets that are sometimes on the opposite side of the earth. Too often, after cutting down the trees, he abandons an area, and moves on to other forests where he repeats the process. Parts of northern Michigan and Wisconsin have been devastated by such methods. Lumbermen might better organize operations that would ensure permanent settlements. In Europe woodsmen more often use selective logging and other methods to perpetuate the forests and keep steady employment in their local areas. Forests in Finland, Sweden, Switzerland, and Germany are managed in this way.

Population density is low in forested regions so long as a growing forest occupies the land. Whether agricultural settlement follows cutting of the trees depends on the soil, climate, and demand for land. Most of the good farm land in western Europe and the eastern United States was once forested. Wooded areas in populous countries are usually restricted to mountains and hills or areas on which the soil is poor.

Mining. The development of mining on a large scale is associated with the needs of our machine age. In ancient times man's requirements for minerals were small and consisted of stone, clay, salt, and a few metals. Since minerals are distributed very unevenly in nature, mining operations have to be carried on where the ores, fuels, or rocks occur. Mineral occurrences situated near centers of population are particularly profitable because costs of shipment are reduced; this circumstance allows exploitation of low-grade ores that would be impossible otherwise. Ore containing only 20 to 30 per cent iron is used at nearby furnaces in Birmingham, Alabama, and in England, while only ore carrying twice this iron content is mined profitably near Lake Superior, which is distant from the furnaces and mills. Deposits of coal and oil have many times proved a major factor in the growth of cities and the establishing of factories that need cheap power. Manufacturing in the "Black Country" of England, the Ruhr Valley in Germany, and the industrial cities in the Donetz Basin and in western Siberia of the U.S.S.R. is based primarily on coal. In Pennsylvania and West Virginia the coal beds are a major factor leading to industrial expansion. Petroleum deposits account for much of the growth of scores of cities in the United States, including Oklahoma City and Tulsa, Oklahoma; Bakersfield, California; Casper, Wyoming; and Beaumont, Texas.

Metal mines often are located in mountains, sometimes at such high elevations or so isolated that no one would reside there if veins of ore had not been discovered. Many mines are short-lived, and the mining towns are abandoned after the deposits are exhausted. Some deposits are so extensive, however, that they are productive for centuries; and a few have been mined for over 2,000 years. The Río Tinto copper mine in Spain, the Cornwall tin mines, and the mines at Potosí, Bolivia, and in the Keweenaw Peninsula in upper Michigan have been major producers of metals for many years. Coal and the base metals like iron, lead, and copper require cheap transportation or moderate closeness to market in order to be profitably mined. In contrast, gold and precious stones can come from a remote wilderness, desert, or jungle to which transportation is difficult and charges high, because their value is so great that the expense for freight can be disregarded. It should be clear, however, that the high expense of operation would permit only rich deposits, even of gold and diamonds, to be worked in out-of-the-way places to which all food, machinery, and labor may have to be brought.

Fishing. Fishing is done both by natives for their major support or to supplement other food sources and by commercial fishermen who sell their catch as a means of livelihood. Nearness to fishing grounds is a requirement for natives using canoes and small boats, but commercial fishermen in large seaworthy ves-

sels may journey many hundreds of miles from the home port to the fishing areas. French fishermen from Brittany, for example, regularly sail for summer fishing off Iceland and on the banks of Newfoundland. The great commercial fishing grounds are on the banks or shoal water near the continents in mid-latitudes. The home ports for commercial fishermen are near large cities if the fresh fish are to be sold. Gloucester and Boston, Massachusetts; Grimsby and Yarmouth, England; Bergen and Trondheim, Norway; Ketchikan, Alaska; and Monterey, California, are examples of important fishing ports. Soils near fishing coasts tend to be unproductive. They are often sandy, swampy, rocky, or otherwise unfavorable for agriculture; under such conditions men turn to the sea for a living.

Geography in Relation to Other Fields of Knowledge

Geography is a very broad subject, with many overlapping applications within both the physical and social sciences, as indicated in Fig. 1. The chart shows some of the geographic phases in selected fields of knowledge, with a core of geographic material that makes up the substance of the subject. This core is represented by the hub of the wheel: the spokes are the connections between geography and many of its allied academic disciplines, which are shown as the rim of the wheel.

A brief description of some of geography's relationships to other subjects will suggest a few of the entertaining and instructive bypaths that the trained geographer may investigate.

Place Names. The study of place names in any area may indicate the progressive exploration and settlement by peoples of different nationalities and languages. Indian names of

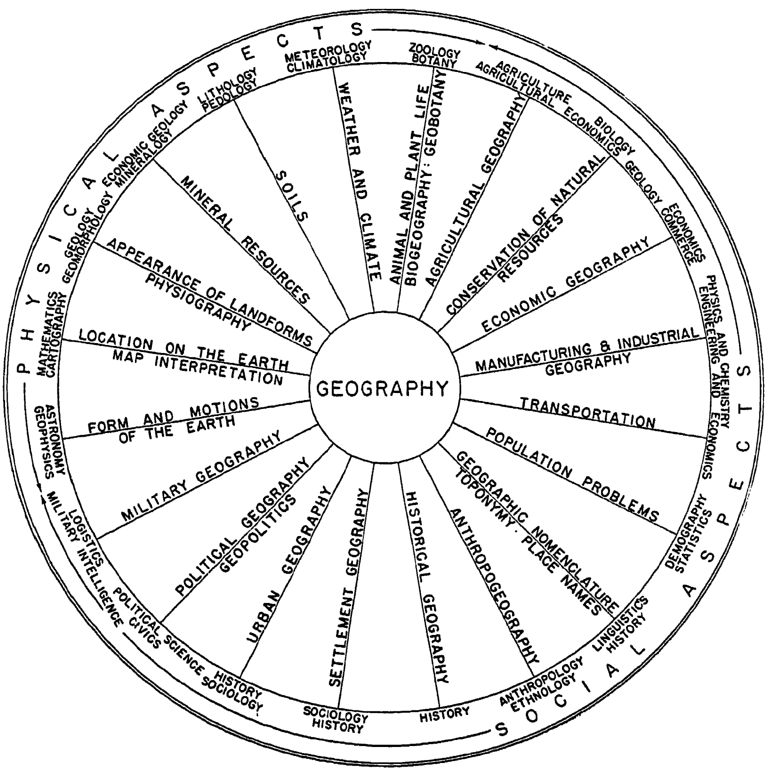

FIG. 1. The relation of geography to other academic disciplines.

places are used in all parts of the United States and sometimes, as in Wisconsin, are common. Names of French origin are frequent in the northern states and down the Mississippi Valley to New Orleans. Spanish place names are favorites in the Southwest, and Spanish is a legal language in New Mexico, where many people speak it as their native tongue. English geographical names predominate along the Atlantic seaboard, and many English names applied to mountains, straits, harbors, islands, and other coast features of the Pacific Northwest were those given by early English navigators and explorers.

Historical Geography. The history of a region is intimately connected with the changes in land and resource utilization. In the region of the upper Great Lakes, for example, the first Europeans sought only furs. Later they exploited the timber, iron and copper ore, and fish and used the Great Lakes for carrying goods. Today some residents are dependent on farming, use of the region for summer recreation is increasing, and waterfalls are being developed for power and manufacturing. The routes of exploration and the peopling of an area depend on the location of passes through highland barriers, navigable rivers, the type of vegetation, the fertility of the soil, the amount of snow, and many other factors. It took the English colonists along the Atlantic coast twice the time to work their way across the ridges and through the forests of the Appalachians to the prairies beyond than was required for men to go from there to the Pacific over country that is generally open plains and deserts. In contrast, French settlers entering the St. Lawrence Valley found a system of waterways whose short portages led them quickly to the interior of the continent. Rivers have proved valuable routes of exploration and penetration in many lands, including the Congo Basin, Siberia, and the Yukon and Columbia basins.

Military Geography. Military campaigns are planned to take advantage of easy routes and favorable weather. In the Revolutionary War, England tried to separate the colonies along the Hudson River–Lake Champlain trench. In completing the conquest of the Mississippi River by the capture of Vicksburg in 1863 the North divided the Confederate States and thereby hastened its victory over the South. German armies won their only victories over Russians during the summer months; but the Russians, more experienced with campaigning in cold and snow, were successful in their winter offensives. Rain, fog, wind, and waves are other handicaps to military operations, as demonstrated in the landings on Normandy beaches. The locations of mineral deposits, raw materials for manufacture, and productive land are factors a country should consider when beginning an invasion of a neighboring territory.

Weather and Climate. A satisfactory understanding of the behavior of the atmosphere is essential as a background for the appreciation of human activities of all kinds. It is difficult to think of a single occupation that is unaffected by the weather. Members of the medical profession, for example, are aware that seasonal changes of humidity and temperature in mid-latitudes are responsible for marked increase in the incidence of certain diseases, especially respiratory afflictions. Weather changes affect a wide range of commercial activities, such as the volume of gasoline sales, evaporation of stored gasoline, marketing of perishable vegetables, heating installations, use of insulation in houses, and sales of beverages, both hot and cold.

It is most essential that the merchant be aware of the effects of weather on his trade. Unwise purchases of seasonal goods may be evidence of a lack of judgment that will determine whether the business will succeed or fail or show profit or loss. Fur wearing apparel, for example, will enjoy a brisk demand at a certain season in mid-latitudes; in high latitudes it is almost always in demand; but in the tropics garments made of fur are almost useless unless the altitude is high.

Agricultural Geography. The entire structure of farm activities is closely bound to geographical conditions. A successful farmer must

know the capacity of his farm for producing to the utmost without declining in fertility. The size of his fields may be governed by the soil's ability to produce, and their very shape may be related to the relief of the land, particularly in hilly and mountainous regions. Whether the farmer sows winter wheat, spring wheat, rye, or potatoes is in itself largely governed by the weather and climate of his locality. His farm activities during the course of the year are closely tied to the weather. Too much rain in harvest season, early autumn frosts, or late spring floods may interfere with farm routines to an extent that few but the farmer himself realize; and, if the farmer's work is a failure, those who depend on his products for food may starve before crops can be harvested during the following season.

Urban Geography. Some of geography's expressions in human activity are comparatively simple, particularly among primitive men, but one phase of geography that tends toward extreme complexity is the study of agglomerations of human beings, interdependent and living in close proximity to each other. The whole study of cities—their landscapes, functions, related parts, and general geographic character (as one writer expresses it, their "personality")—is a problem taxing the most capable students of geography. The mere mapping involved in a city study is difficult, but geographic studies of cities aid in understanding why a given section has deteriorated in character or why a certain suburb is favored for residence purposes while others fail to develop. Geographers frequently assist in city planning by such contributions as making recommendations on city zoning, the improvement or routing of transport facilities, and the resources available for industry.

Conclusion

The preceding paragraphs directly and by implication suggest some of the geographer's activities and the relationships of his subject to allied disciplines. These and other topics will be developed at greater length in succeeding chapters of this volume, and it is unnecessary to elaborate on them as special subjects at this point in the discussion. The thoughtful student and his teacher should supply many examples of sound geographical observation from their own experience and their own home locality. In this way, the whole subject of the geography of this earth becomes a vital bit of the individual's knowledge and contributes greatly to his wide understanding of his fellow man, his community, and his nation.

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CHAPTER 2: *The Earth and the Tools of Geography*

Since ancient times men have wondered about the earth. They observed and endeavored to explain the succession of day and night, the changes in position of the sun and stars, and the occurrence of the seasons; but centuries passed before they finally discovered the facts about the earth and its position in the universe.

Relation of Earth, Moon, and Sun. The earth is one of the planets of the solar system. The planets revolve around the sun, and in turn some planets have moons that revolve around them. The earth has a diameter of approximately 8,000 miles and is about 25,000 miles in circumference at the equator. Our moon has a diameter of over 2,000 miles and is the largest moon in the solar system. It is the brightest object in the night sky, and its attraction is the chief cause of the tides. The sun is one of millions of stars with temperatures so high that they are self-luminous. The sun is a glowing ball, 865,000 miles in diameter, a distance nearly four times greater than the distance of our moon from the earth. Only a tiny proportion of the total radiant energy emitted by the sun reaches the earth, but this is sufficient for the growth of plants and animals and the maintenance of all activities and processes requiring heat and light.

The earth revolves around the sun once each year (365 days 5 hours 48 minutes 46 seconds) at an average distance of 93 million miles in a path called the *orbit*. The moon completes one revolution around the earth in 27⅓ days, but the entire series of phases from the new crescent moon to full moon and back again requires about 29½ days because the earth has also been moving during this time along its own orbit. The phases of the moon result from the angle at which the illuminated face of the moon is seen from the earth.

Shape of the Earth. The earth is known to be of almost spherical shape, although it is so large that to the eye any extensive plain appears flat—apparently disappearing at the horizon. Technically it is called an "oblate spheroid" because it is slightly flattened at the poles. One proof of the shape of the earth comes from the careful calculation of the lengths of degrees of latitude, which increase slightly (7/10 mile) from the equator to the poles. This proves that the equatorial diameter of the earth is longer by 26 miles than the length of the axis from pole to pole. The earth's shadow cast on the moon during an eclipse of that body is circular, another proof of the earth's shape, since a sphere is the only geometrical solid that would produce a circular shadow at all angles. Further proofs include the facts that hulls of ships disappear before their masts as they sail away from port and that the smoke of steamships may be seen when the boats themselves are invisible below the horizon.

The most remarkable proof of the earth's shape comes from photographs taken during a flight 70,000 feet into the stratosphere, which actually show the earth's surface on the horizon as a curve instead of a straight line. The curvature of the earth is also clearly shown in photographs taken in connection with a V-2 rocket that was sent over 100 miles into the air above the earth. The oft-stated proof of the sphericity of the earth, that of sailing around it and returning to the starting point, is inconclusive; for, if the earth were flat with the North Pole at the center, it would be possible to go around the pole and return to the place of departure. Further-

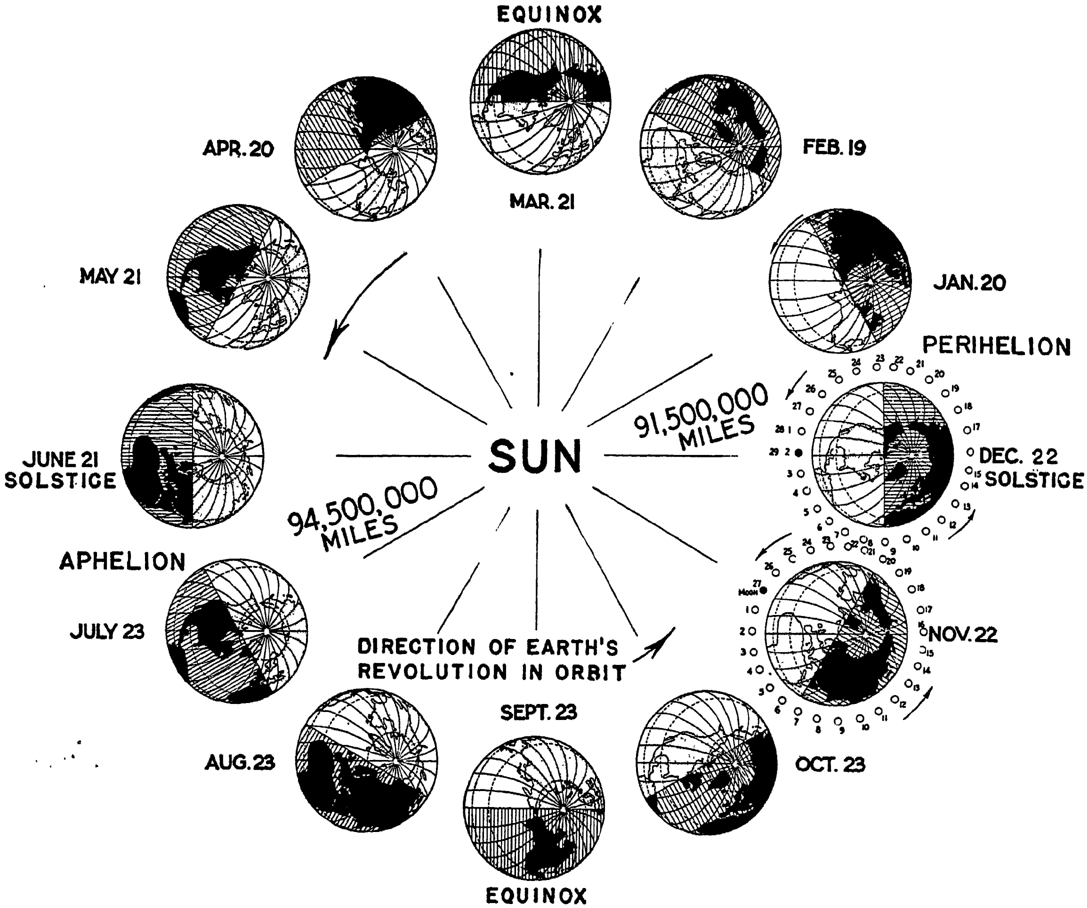

FIG. 2. Earth's relationship to the sun throughout the year. (*After "The Earth in Space," A. K. Lobeck, published by The Geographical Press, Columbia University, New York.*)

more it would be possible to sail around a world whose shape was cylindrical.

Rotation and Revolution of the Earth. Two motions of the earth exert profound geographic effects. These motions are (1) rotation of the earth on its axis once each 24 hours, causing day and night, and (2) revolution of the earth around the sun once each year, a factor in the change of the seasons (Fig. 2).

Evidence of rotation is found in the rising and setting of the sun, moon, and planets, and their daily movements across the sky. The circular motion of the constellations of fixed stars completed in 1 day around the polestar, toward which the axis of the earth points, is further proof (Fig. 3). Rotation on an axis locates the two poles and the equator, from which measurements are made. Some deflection of winds, ocean currents, and freely moving objects is caused by the earth's rotation.

Proof of the revolution of the earth includes the occurrence of seasons and the apparent changes in elevation and location of stars at different times of the year.

The distance of the earth from the sun varies some 3 million miles during the year. This affects the solar energy received by the earth slightly but not enough to bring about seasonal changes. On January 8, the earth is in *perihelion,* or nearest to the sun, at a distance of about 91,500,000 miles. On July 8,

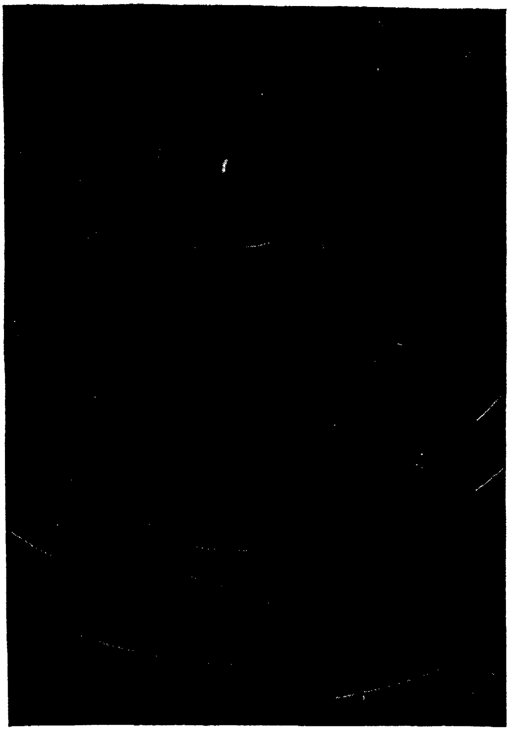

FIG. 3. A 2-hour exposure of a film directed at the North Star, which appears in the photograph as a bright dash at the center of the vortex. The North Star is about 1 degree and 25 minutes out of line with the extension of the earth's axis into space; hence the North Star appears to have movement sufficient to register as a dash instead of a dot in the photograph.

the earth is in *aphelion,* or farthest from the sun, about 94,500,000 miles. Obviously distance from the sun is not a controlling factor in causing seasons, because the earth is nearest the sun during the winter in the Northern Hemisphere.

The earth in its revolution subtends from the *ecliptic,* or plane bounded by the earth's orbit, an equal area in equal time. This causes the earth's forward progress in its orbit at perihelion to be somewhat faster than at aphelion, and a slight variation in length of the mean solar day results.

Inclination of the Earth's Axis. The axis of the earth inclines almost 23½ degrees to the normal to the ecliptic or 66½ degrees to the ecliptic. As the earth revolves around the sun, this inclination produces a change in the directness of the sun's rays and in the time and direction of sunrise and sunset, thereby affecting the length of time the sun shines each day. Changes in length of day and directness of the sun's rays are the chief causes of the earth's seasons. The inclination of the earth's axis is the factor that determines the location of the Tropics of Cancer and Capricorn and the Arctic and Antarctic Circles.

Equinoxes and Solstices. Seasonal changes in the length of daylight and darkness periods are the result of the revolution of the earth in its orbit, the inclination of its axis from the plane of that orbit, and the constant position (parallelism) of the axis. If the earth's axis were perpendicular to the plane of the ecliptic, daily amounts of radiant energy from the sun would approximate what we now have at the equinoxes, days and nights all over the world would be of the same length, and perceptible seasonal changes would be absent.

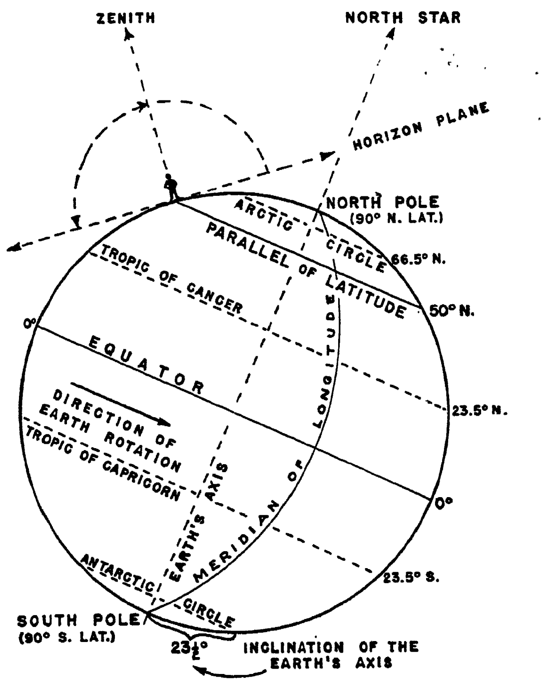

FIG. 4. The different terms used in connection with the earth. Distances are necessarily limited on the diagram; actually, the North Star is far out in space above the North Pole, and one's zenith is a point infinitely distant above the horizon plane.

The *vernal equinox* in the Northern Hemisphere (March 21) is the day when the point of verticality of the sun's rays crosses the equator moving north; the *autumnal equinox* (September 23) is the day when the vertical sun's rays cross southward over the equator (Fig. 2). The *summer solstice* of the Northern Hemisphere (June 21) is the day when the sun's rays are inclined their greatest degree northward (maximum declination), and the *winter solstice* (December 22) is the day when the maximum southward inclination is attained in the Southern Hemisphere. The four dates given are customary, but one or more may vary a day in some years. The word equinox signifies that all parts of the earth have equal periods of day and night—but in actual practice there may be variations of a few minutes. At a solstice the vertical rays of the sun reach their maximum distance north or south of the equator and after a momentary pause begin to return equatorward.

The sun's position in the sky changes profoundly during the year with increase of distance from the equator. At the equator during the year the rising and setting sun varies the least from due east and west of any parallel, and the days and nights have equal length. The higher the latitude north of the equator, the further north of east the sun rises and the further north of west it sets during the summer and the further south of east and west respectively in the winter. The length of day and night also vary widely during the year. The Southern Hemisphere has seasons and length of days the reverse of those in the Northern Hemisphere.

Five lines encircling the earth are important for reference. The equator placed midway between the poles is one of these. To a person on the equator, at both equinoxes, the sun is vertical—that is, in its zenith—at noon, with a maximum change to 23½ degrees from the zenith at the time of each solstice. The apparent northward movement of the sun's bundle of rays at our summer solstice halts at latitude 23½°N.; at this point an imaginary line is drawn around the earth, parallel to the equator. This is known as the *Tropic of Cancer*. The *Tropic of Capricorn* is placed in latitude 23½°S. to mark the southward limit of the sun's advance in December. Similarly the *Arctic Circle* is located at latitude 66½°N., or 23½ degrees below the latitude of the North Pole, while the *Antarctic Circle* is located at latitude 66½°S. Thus the inclination of the earth's axis at an angle of nearly 23½ degrees from the plane of the ecliptic determines the positions of these imaginary lines on the earth's surface.

Changes in Length of Day. The altitude of the sun at noon on an equinox is the complement of latitude. There are 90 degrees of latitude from the equator to a pole. At 10 degrees north of the equator, the sun's altitude at noon of the equinox is 80 degrees above the horizon toward the south. If the sun were 60 degrees above the horizon, the latitude would be 30 degrees. The same mathematical relationship holds for other latitudes.

At the North Pole the sun appears above the horizon at noon on March 21 and on successive days steadily rises to a maximum height in the sky, until on June 21 it reaches 23½ degrees above the horizon during the entire day; it then declines each day until it disappears below the horizon at noon on September 23.

The Arctic Circle (latitude 66½°N.) is 43 degrees from the Tropic of Cancer (23½°N.). On June 21 the sun's rays are straight above the Tropic of Cancer; and, since the altitude of the sun is a complement of latitude, the sun is 47 degrees above the south horizon at noon at the Arctic Circle and just reaches the northern horizon at midnight. In contrast, on December 22 there is a 24-hour period that has no direct sunlight whatever. Between the Arctic Circle and the North Pole gradations from 24 hours to 6 months occur in length of day and night.

The altitude of the sun and the length of the day in the Southern Hemisphere during the winter and summer solstices are the reverse of those described as existing during those times north of the equator.

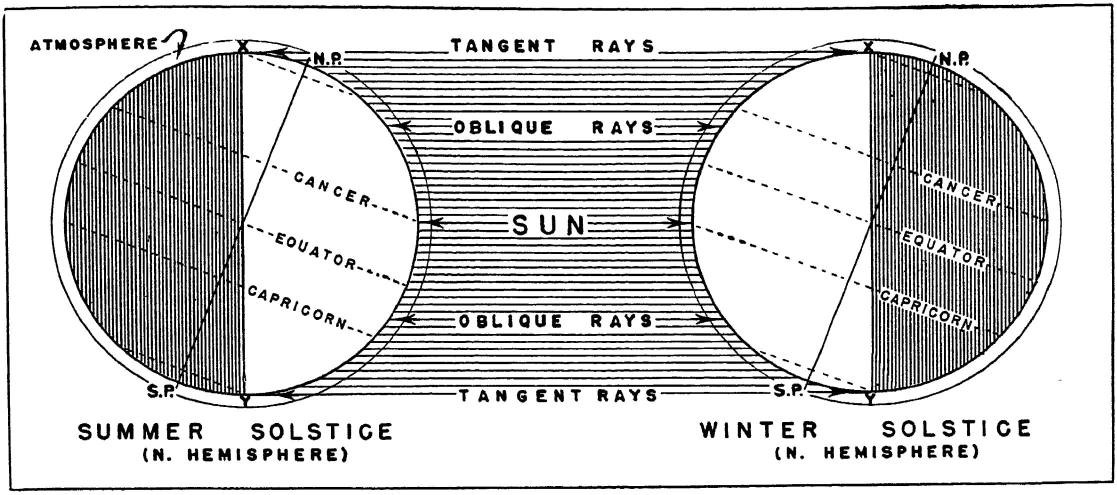

FIG. 5. Reception of solar radiation on the earth at the time of the Northern Hemisphere solstices. Line *X-Y* is the circle of illumination. Note the apparent migration of the vertical rays from the Tropic of Cancer to the Tropic of Capricorn between the summer and winter solstices. Note also that the vertical rays penetrate the earth's atmosphere directly, while oblique and tangent rays must traverse a considerable depth of atmosphere before reaching the earth itself. The depth of the atmosphere has been exaggerated on the diagram, in relation to the size of the earth. N.P. and S.P. are North Pole and South Pole, respectively.

In the United States there are marked differences in length of days and nights during the year. Along the Canadian border (latitude 49°N.) in June the sun is above the horizon 16 hours per day, but in December it appears for only about 8 hours. Differences in length of day are much less in the southern states, where at the summer solstice daytime lasts about 14 hours, in contrast to only 10 hours at the winter solstice. Only half the earth's surface may receive solar energy (*insolation*) at any one time, and the imaginary line that separates the lighted from the darkened half of the globe is known as the *circle of illumination* (Fig. 5).

The long periods of summer sunshine permit spring wheat to mature in the relatively high latitudes of northern Alberta and Saskatchewan in Canada. In most years it will ripen in central Alaska in 3 or 4 months of summer days, although the same grain would require 5 or 6 months to mature in Nebraska. Garden vegetables also grow very rapidly in the long days of the high-latitude summer. In Alaska radishes can be harvested 2 weeks after planting, and 30-pound cabbages are not uncommon. In addition to the period of direct sunshine the long twilight of the northern summer, lasting nearly an hour after sunset, occurs because the oblique (slanting) rays of the sun follow a longer path and are diffused by the greater thickness of air which they must penetrate. In the tropics the sun's rays penetrate the earth's atmosphere directly, and twilight is much shorter.

Location

Latitude. A starting point on the earth's surface is needed for the calculation of distances, just as in American cities streets are numbered east and west from a north-south thoroughfare, and north and south avenues from some central east-west street. The equator, an imaginary line midway between the poles, is obviously the natural starting point for measuring latitude or the distances north and south. The imaginary circular lines

around the world used to measure latitude are named *parallels* (Fig. 4). Since the distance from the equator to either pole is one-fourth of the total circumference of 360 degrees, there are 90 degrees of north latitude and 90 degrees of south latitude.

Latitude may be calculated from the altitude of the sun above the horizon, and this observation is usually taken at noon. At either equinox, the sun is vertical above the equator at noon. On that day an observer located 1 degree from the equator would see the sun 1 degree below his zenith; if he were 20 degrees from the equator the sun would be 20 degrees from his zenith, and so on until at each pole he would see the sun just touching the horizon at noon. To determine latitude on an equinox, the observer merely measures how many degrees the sun appears in the sky below his zenith at noon (secured by determining the altitude of the sun above the horizon in degrees and subtracting from 90) and whether the sun is in the south or in the north. The measurements are usually made on an instrument known as a *sextant*. If the observer sees the sun toward the south at noon on the date of the equinox he is in the Northern Hemisphere, and if he sees the sun toward the north he is in the Southern Hemisphere. On any other day of the year, calculations are taken from the parallel where the sun stands vertically overhead at noon.

From March 21 the vertical noonday sun appears to an observer to move northward until it reaches the Tropic of Cancer on June 21, and it then appears to return to the equator on the autumnal equinox (September 23). From that date to the winter solstice (about December 22) the vertical noonday sun apparently moves southward, until it reaches the Tropic of Capricorn on the winter solstice, and then returns to the equator to start the process all over again on the vernal equinox (March 21). When calculating latitude, in actual practice, a navigator may refer to a book of tables called the "Nautical Almanac," which will give his latitude directly for a given altitude of the sun on a certain day of the year. Northern Hemisphere latitudes may be calculated at night from the polestar, which is nearly overhead at the North Pole and just touches the horizon at the equator. The height of the star in degrees above the north horizon at any time of night on any date corresponds to the latitude of the observer. An easy proof of the rotation of the earth is a time photograph taken on a clear night with the camera pointed at the polestar. Because of the earth's rotation, the other stars appear as curving lines circling around the polestar (Fig. 3).

Longitude. The starting point for measurement of longitude, or distance east and west, is wholly arbitrary and might begin at any selected *meridian,* which is the name chosen to designate an imaginary line from pole to pole (Fig. 4). In practice, most nations calculate longitude from the meridian that passes through Greenwich, site of an observatory at London, England. This is known as the *prime meridian.*

Longitude is calculated 180 degrees both east and west of Greenwich, at which point the longitude measured in one direction changes to the other; that is, when one travels westward and goes 1 degree beyond 180 degrees west longitude, he reaches 179 degrees east longitude, and his position is then designated in decreasing number of degrees until he returns to the prime meridian. The length of the circumference of parallel circles of the earth decreases from the equator to the poles, reaching zero at the poles; the length of a degree of longitude decreases accordingly, from approximately 69 miles in length at the equator to 50 miles in the central United States and 0 at the poles.

Since the earth rotates 360 degrees of longitude each 24 hours, a movement of 15 degrees on the earth's surface parallel to the equator will change the time by 1 hour. If a man travels eastward from Greenwich 15 degrees, his time is 1 hour ahead of Greenwich (Fig. 6). If he goes westward, it is 1 hour behind Greenwich. New York, at approximately 75

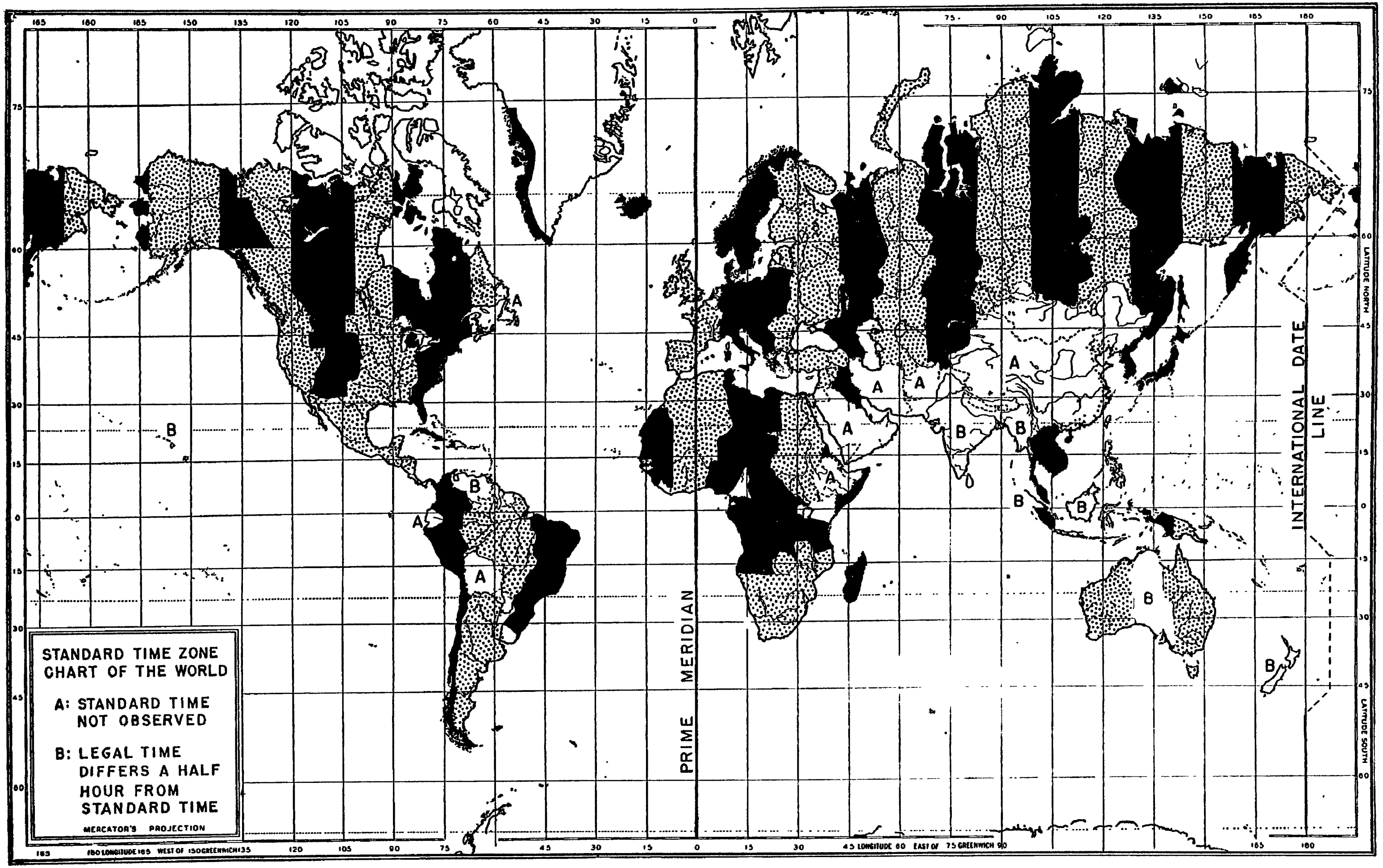

FIG. 6. Standard time zones of the world, shown in black and by means of stippling. Note that the same time of day is observed within each zone for a distance approximately 7½ degrees of longitude on either side of the standard meridians. Note the four time zones in the United States. (*Mercator-type base map by R. B. Hall. Courtesy of the cartographer and the publishers, John Wiley & Sons.*)

degrees west longitude (actually on the 74th meridian), is 5 hours behind London's time. Thus when it is noon in London it is 7 A.M. in New York. It is 6 P.M. in Calcutta, 90 degrees east longitude, when it is noon in London. The solar time in both Northern and Southern hemispheres is identical on the same meridian.

International Date Line. When it is noon at Greenwich on the prime meridian, it is midnight on the 180th meridian, and a new day begins there. The 180th meridian is called the *international date line* (Fig. 6). It is convenient to have one nation observe a single date; for this reason the eastern end of Siberia is included with the day west of the international date line, while the whole of the Aleutian Island group observes the date east of the date line. In going westward around the world, a traveler moves with the apparent sun movement, and more than 24 hours elapse between noon of one day and noon of the next. During his journey he sees one less sunrise and one less sunset than the stay-at-homes so that, upon returning to his starting point, he is a day behind residents there. On traveling eastward around the world he goes toward the sun, and less than 24 hours elapse between successive noons. Upon arrival at the starting point, the traveler finds that he has seen one more sunrise and one more sunset than those who stayed at home and is one day ahead. To avoid such complications, a day is added or subtracted on crossing the international date line. A change in date is made at midnight of the day that the line is crossed. If the line is crossed going west on Sunday, the following day becomes Tuesday. The extra day when the line is crossed going east is called *meridian day*.

Maps

The large amount of information available in geography makes it desirable that maps, graphs, and other visual aids be used as tools that enable students to visualize the geographic setting and to classify and interpret various data, including statistics. Maps constitute the most important geographic tool because they are drawn to scale and information is plotted in a form that is clearly seen and quickly grasped. Relations between the physical conditions within a given region and the human activities carried on there, or the use of a given area by man, are best shown on maps. Other useful visual aids in geography include graphs, census reports and other sources of statistics, gazetteers, atlases, photographs and motion pictures, books, magazines, official reports, and other published information. These should be supplemented whenever possible by personal investigation and inspection of the area, though relatively few students are able to enjoy the privileges of extensive study in the field.

Magnetism and the Magnetic Pole. Experience shows that our earth is a great magnetic field, and advantage is taken of this to determine directions by means of the compass. Because of the earth's magnetism a bit of magnetized steel will align itself so that one end always points toward the north magnetic pole. The location of this point is subject to change, and different explorers have found the magnetic pole in different places. The site is about 1,300 miles south of the true North Pole and is probably located near latitude 71°N. on the Boothia Peninsula north of Hudson Bay or on nearby Prince of Wales Island. Since the compass points to the magnetic pole, it follows that in most parts of the earth that instrument varies in direction from the true north. The line of no variation of the compass is called the *agonic line,* and it passes through western Michigan and off the Atlantic coast near Savannah. East of the agonic line the compass points to the west of true north, and to the west of the line the readings are east of true north. In general the farther north one goes the greater is the variation of the compass. Lines connecting places of equal variation (that is, declination) of the compass are

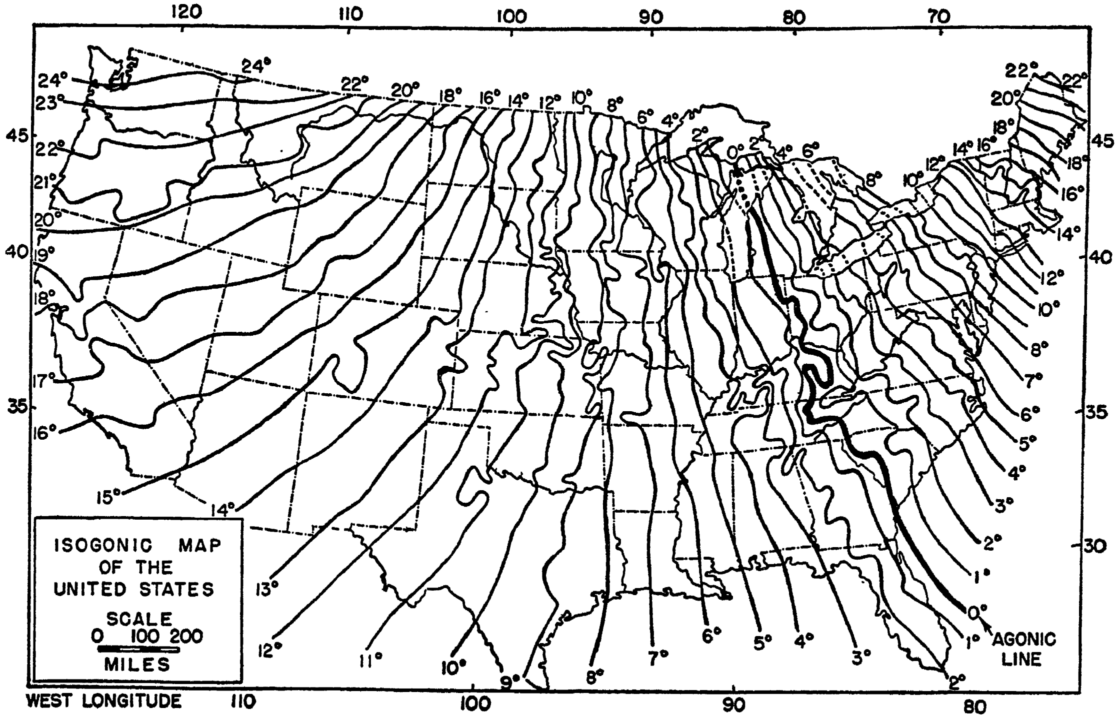

FIG. 7. Isogonic map of the United States. The diverging lines of magnetic declination will come together at the north magnetic pole in northern Canada.

known as *isogonic lines* (Fig. 7). The compass is used by navigators, explorers, and surveyors and is of great use in the mapping of the earth's surface.

Scale of a Map. Most maps are drawn to a definite scale. The scale of a map is the relationship it bears to an actual distance represented on the earth. Scale is usually expressed as a ratio or fraction, with one unit on the map representing a number of the same units measured on the land. A scale of 1:63,360, for example, indicates that 1 inch on the map represents the number of inches in 1 mile of actual distance on the earth's surface. Many maps indicate the scale by a measured line in addition to the ratio. A scale of 1:62,500 would be a larger scale than 1:125,000. Much of the world is being mapped on the scale of 1:1,000,000. This scale is one-sixteenth that of 1:62,500, which is used on many topographic maps. It may be noted that the scale of 1:62,500 is not far from the scale of 1 inch to 1 mile.

The scale selected by the map maker depends upon the detail desired and the purpose for which the map is to be used. A map of a continent on a scale of 100 miles to 1 inch might be a convenient ratio, but a state map may need to be issued on a scale of 10 miles to 1 inch or smaller, and a county map perhaps should be drawn on a scale of 1 mile to 1 inch. Some maps, for example, Mercator's projection, use different scales on different parts of the map. On the other hand, the scale of a globe applies in any part and any direction. It is apparent that the larger the figure in the ratio of the scale, the smaller the scale of the map.

The Globe. In studying the earth, its movements, and its relations to the sun, it is necessary to represent its appearance as correctly as possible. This can best be done by using a globe, which is the most satisfactory representation of the earth that has been devised because it shows the real position of points on the earth in relation to each other. On a

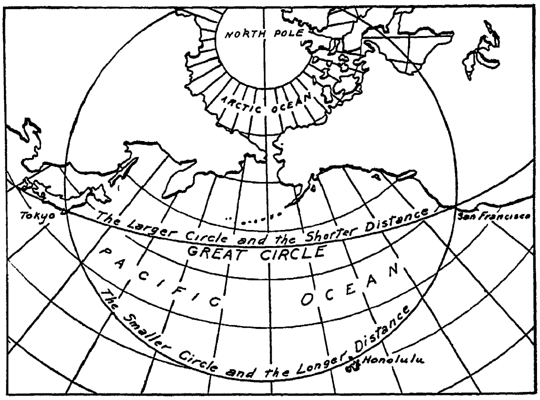

FIG. 8. The great-circle sailing route is the shortest distance on the earth's surface between San Francisco Bay and Tokyo.

globe, too, the reason for the northerly location of sailing routes can be demonstrated. Because the distance around the world becomes less when one goes away from the equator, it follows that both mileage and time can be saved by routing ships and aircraft along the great circles in high latitudes. A taut string stretched between San Francisco and Tokyo on a globe shows that the shortest (great-circle) route is a short distance south of the Aleutian Islands, yet the route would appear to be longer (Fig. 8) when plotted on a flat Mercator map. The globe presents the actual short-distance routes that will be used as soon as safety is assured in flying the hitherto remote and dangerous polar areas. These routes follow the arcs of great circles, which are the shortest distances between any two given points on a sphere or globe. Thus the shortest distance for airplane travel from Chicago to Moscow is across the polar sea along a great-circle route.

Facts about the earth taught to students in the primary grades can best be presented by means of the globe. It is accurate but not readily portable. It cannot be folded into books and for many purposes is too awkward and unhandy. Globes 8, 10, and 16 inches in diameter are handier in measuring distances between points than are 12- or 14-inch globes, because the scale of the globe is in even numbers of miles (1,000 miles to the inch for the 8-inch, 800 miles for the 10-inch) while the 12- and 14-inch globes have scales with odd numbers and fractions of miles.

Map Projections. In making flat maps certain approximations must be made, since no flat surface can perfectly represent the surface of a sphere. The different schemes used to construct maps are called map projections. These consist of networks or grids of lines representing meridians and parallels.

Several characteristics of maps are particularly desirable, and the relative importance of these characteristics depends upon the use for which a map is intended. Since it is impossible to represent a curved surface upon a flat surface without distortion, the map maker or cartographer should select the map projection that best suits his purpose. If the ideal map could be designed, it should show (1) correct shape or form of land and water bodies, (2) correct area, (3) correct location, (4) northward direction at the top of the map, (5) the shortest distance between two points by a straight line, (6) constant compass direction between two points by a straight line on the map, (7) all of the world on one map, without interruption. Some of these good features may be had in a map projection, but only at a sacrifice of part or all of the other features. It is impossible for any map that shows a large part of the earth's surface to represent both shapes and areas correctly. One or the other of these objectives must be sacrificed. Numerous map projections have been constructed by cartographers. Each has certain advantages and disadvantages. In their choice of a map, cartographers keep in mind the type that will best show what they want to indicate by the map.

The following projections are among those used most frequently:

1. *Hemispherical* projections represent the world as two circles, and of all the flat world maps these most resemble a sphere and are of much use to the geographer. Areas on many hemisphere maps are nearly correct, but directions are hard to follow because the meridians and parallels are generally curved. When used

for showing the whole world the map is split into halves, making it difficult to follow a parallel or route from one hemisphere to the other. Among the many types of hemispherical maps in use are the orthographic, stereographic, globular, and Lambert's azimuthal.

The orthographic projection uses straight lines for parallels and curved lines for meridians either side of the middle meridian, which is straight. Both parallels and meridians are progressively closer together toward the periphery. Our view of the moon is like the view of the earth that appears on the orthographic projection.

The stereographic projection, when used for the familiar eastern and western hemispheres, has straight parallels and meridians that meet at right angles at the center of the hemispheres with the remainder of the lines curved and progressing farther apart toward the periphery. Single continents like South America, Africa, Asia, and North America are often drawn on this projection.

The globular form resembles the stereographic but uses meridians that are equally spaced throughout and parallels that are equally spaced at the edge of the hemisphere. This projection is commonly used for hemisphere maps but seldom for other purposes.

Lambert's azimuthal (Fig. 9) is an equal-area projection, and in theory the surface to be mapped is sketched upon the plane tangent to the center of the chosen area. The parallels are concentric circles. The meridians radiate like spokes of a wheel if the pole is at the center of the hemisphere, but when the pole is placed outside the map center the meridians diverge therefrom on broadening curves. This map is commonly used for polar hemispheres and is a good projection for areas of continental size.

2. One of the most familiar of all projections is the *Mercator type* (Fig. 10), invented by a Flemish mathematician over 300 years ago. This projection is constructed with the parallels and meridians at right angles. It is therefore easy to chart the route of a vessel

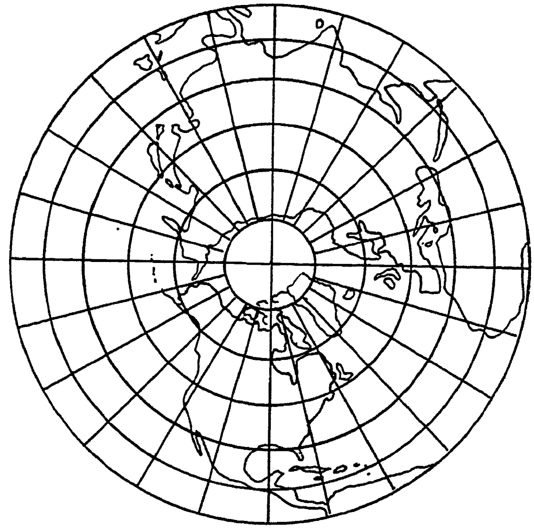

FIG. 9. The polar equal-area map projection, or Lambert's azimuthal, devised in 1772. This hemispherical map distorts shapes, particularly near its perimeter, but it provides accuracy of area throughout the whole map. This quality makes it a valuable map for the geographer. The principle employed can be expanded to include the whole earth and the resulting map will resemble the homolographic projection in Fig. 12.

on such a map, and this style finds wide use in navigation. The relative simplicity of the Mercator map led people to use it for general purposes for which it was not suited. The Mercator projection assumes that the world is a cylinder instead of a sphere and that high latitudes have the same circumference as the equator. This is far from the truth. At the equator, as previously noted, a degree of longitude has a length of about 69 miles, while at 30 degrees of latitude it is about 60 miles long, and at 45 degrees, 49 miles. From there to the poles the length of a degree rapidly decreases until it is zero at the poles, where all meridians converge. To keep directions correct, distances north and south must be exaggerated in the same proportion as those east and west, with the result that distances in Alaska are shown on the Mercator map nearly twice as long as they would be at the equator. In Greenland the distance would be nearly four times as great as it is at the equator. As a result, Alaska is shown

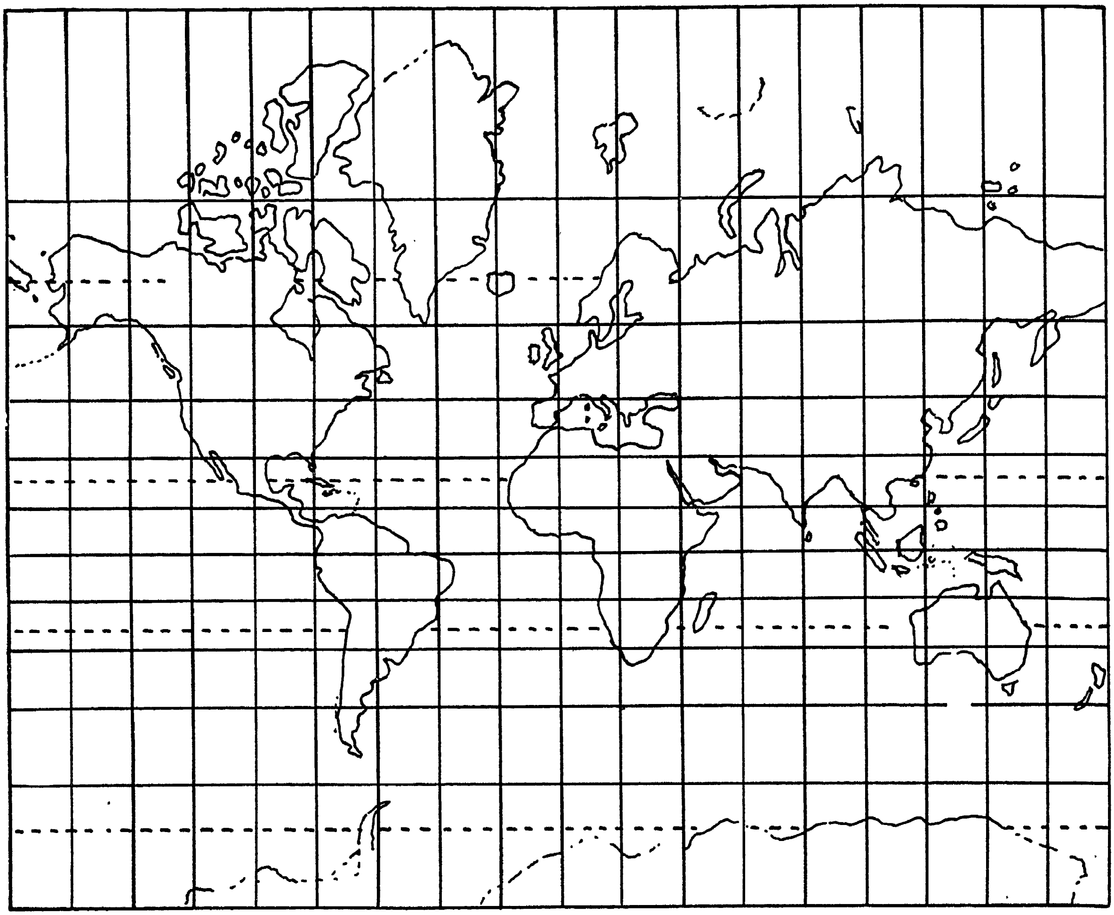

FIG. 10. The Mercator type of map projection, first drawn in 1569. This is a very useful map for navigation, but unfortunately the areas which appear on it are greatly exaggerated in high latitudes, and it should not be used for mapping the distribution of areal data or for measuring distances. (Note that the meridians and parallels appear as straight lines that cross each other at right angles.)

on the Mercator projection four times larger than it should be, and Greenland is sixteen times too large. In reality, Greenland is one-ninth the size of South America and much smaller than Africa, yet the Mercator projection makes it look larger than South America (Fig. 11) and as large as Africa.

Two advantages of the Mercator projection are that the main compass directions are shown at right angles and north is at the top of the map. Furthermore, relative areas within about 30 degrees of latitude of the equator are nearly correct, but students using the Mercator projection maps should keep constantly in mind the great exaggeration of

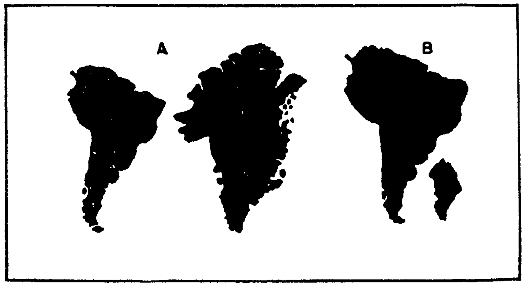

FIG. 11. *A*. South America and Greenland as they appear on a Mercator projection. (South America in reality is nine times as large as Greenland.)

B. The true areas of South America and Greenland as they appear in their correct areal relationship on the globe or on an equal-area map projection.

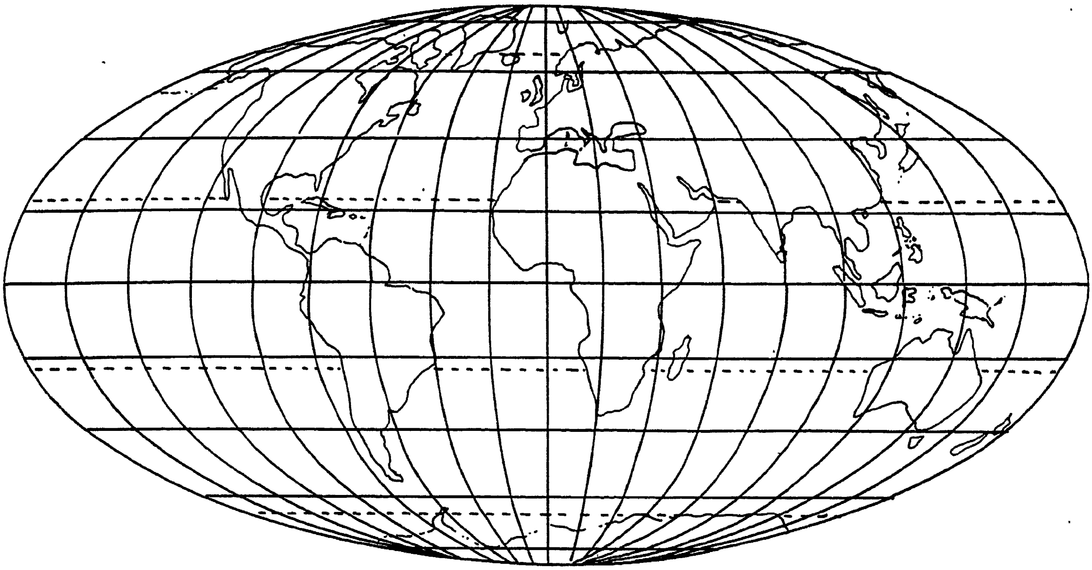

FIG. 12. The Mollweide, or homolographic, projection, with the world drawn upon it. This type of map was devised in 1805, and its peculiar shape results from the doubling of the equatorial axis in relation to the north-south axis. Though maps drawn on this projection will appear greatly distorted in shape, their areas remain true to scale, and hence the map is particularly useful to geographers, economists, and others who map distribution of features on the earth.

areas in high latitudes. Areas near the poles are always omitted.

3. The *Mollweide,* or homolographic, projection (Figs. 12 and 200) portrays the whole world on one map, yet areas are in correct proportion. It is of an oval rather than hemispherical shape, twice as broad as it is high. The parallels are straight lines, getting progressively closer together poleward, but the meridians on either side of the center of the map become more and more curved toward the edges. Thus it is inevitable that land

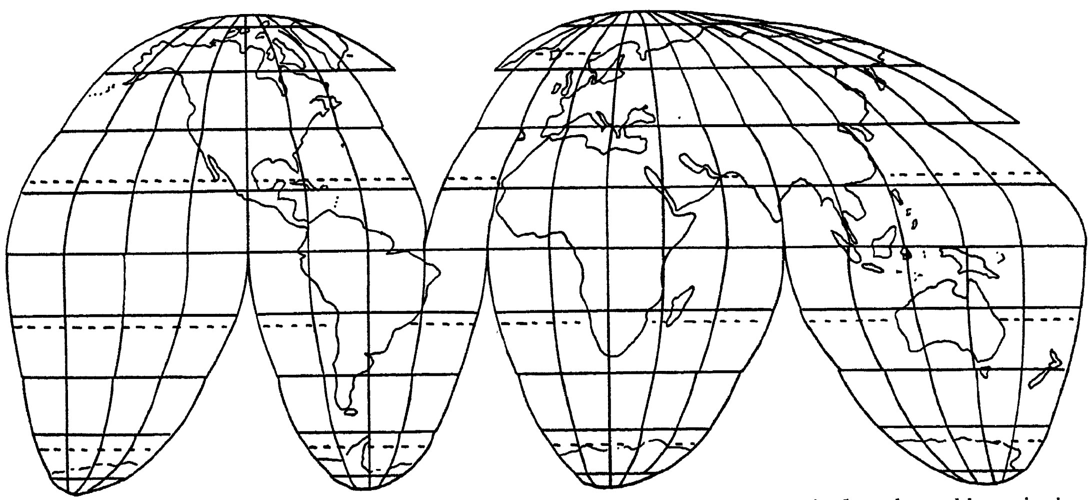

FIG. 13. The homolosine projection, drawn by J. Paul Goode in 1923, is similar to the homolographic projection; but it retains equivalence of area, and the correctness of shape is superior to that of Fig. 12.

shapes appear distorted toward the edges of the map and that the north-south directions are difficult to follow.

The *sinusoidal* projection resembles the homolographic but uses slightly different shapes for meridians and equal spacing for parallels (Fig. 139).

4. To retain the advantage of the correct relative size of land areas of the Mollweide map while overcoming in part the difficulty of following directions, the homolographic maps have been interrupted in order to decrease the curvature of the meridians. The late J. Paul Goode constructed such a map and named it the *homolosine* projection, shown in Fig. 13. This is essentially a sinusoidal projection up to 40 degrees north and south latitude, and beyond that it is a Mollweide projection. It is cut into four parts (quadrants) in the Southern Hemisphere, thereby keeping the meridians nearly straight, while the Northern (or land) Hemisphere is split twice, both times over oceans. Northeastern Asia has highly curved meridians, but directions in other parts of the world are easy to follow. The homolosine map may be divided over the continents instead of over the oceans when it is necessary to map ocean trade routes.

5. The *conic projections,* of which Fig. 14 is one, are commonly used for maps of continents, countries, and states. The meridians are designed to diverge from a point outside the map and are straight. Parallels are represented by curved lines. Thus, on the map of the United States, the student must follow between the curved parallels and diverging meridians, respectively, to get directions. If he carelessly thinks directions are at right angles on such a map, considerable error may result. The 49th parallel appears as a curved line on a conic projection. Actually the most northern part of the United States proper is a little area by the Lake of the Woods in Minnesota, but on the conic map both Washington and Maine look farther north because they are located toward the edges of the map. For large continental areas that are elongated north and south like North America, the *polyconic* projection (Fig. 15) is popular. It is drawn as though many cones of different sizes were fitted onto the sphere. The meridians are curved except for the middle one. The parallels are arcs progressively farther apart toward the sides of the map.

Land Survey in the United States. The first European settlers located their holdings by landmarks such as trees, rocks, stakes, and streams. Where rivers were navigable a frontage on the stream was desired since highways were very poor; hence in tidewater Virginia, Maryland, and Quebec old landholdings are in the form of long strips, each extending back from a comparatively narrow water

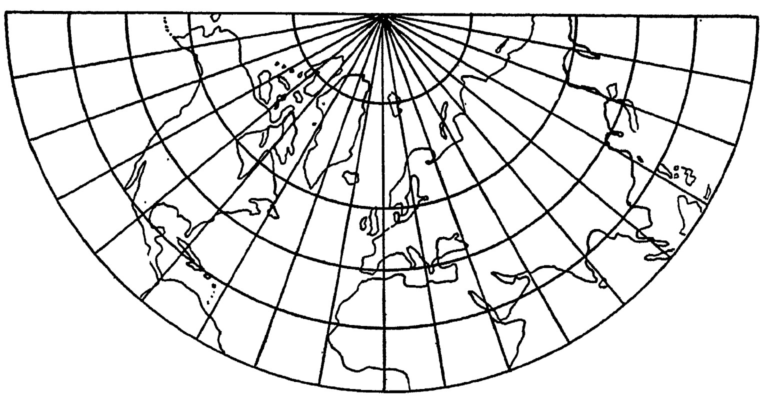

FIG. 14. Part of the Northern Hemisphere drawn upon a conic projection. The distortion on this map occurs near the North Pole and along the equator. The middle part of the map is least distorted. (Note the use of straight meridians and curved parallels.)

FIG. 15. A polyconic projection on which the map of the United States has been drawn. (Note the curvature of both meridians and parallels.) This projection does not have all the qualities desired in a map, but it so nearly attains them that it is an extremely useful grid. Most of the maps published by the U.S. Geological Survey are drawn on this projection.

frontage along which the farm buildings were located. With the extension of settlement inland, a better system of landholding and land surveying was needed, and the land of most of the United States is described under the new scheme.

Principal meridians are run north and south as needed. The first of these to be established now serves as the boundary between Ohio and Indiana. Others are given various names or numbers. A parallel called a *base line* was run east and west from a convenient point on the principal meridian. At intervals of 6 miles, lines were laid out parallel to the base line, intersecting strips of land called *ranges,* which are about 6 miles wide, following the north-south course of the principal meridian. The resulting divisions of land are termed *townships* and are numbered north or south from the base line and east or west from the principal meridian. Thus T. 2 N., R. 5 E. would be a township 6 miles square (36 square miles) on the second tier north of the base line and the fifth tier east of the principal meridian. "T" stands for township and "R" for range. Since meridians converge at the poles, thus decreasing distance between meridians from south to north, it is customary to establish correction lines every four tiers of townships, or 24 miles north and south of the base line, in order that the townships will continue to be approximately 6 miles square. There a new start is made, and roads and fences that follow section lines may have quite a jog or offset at the correction line.

A township is divided into 36 sections, which appear on United States surveys numbered consecutively back and forth beginning at the upper right-hand corner and ending at the lower right-hand corner (Fig. 16). In most states, sections 16 and 36 were donated for the support of public schools, or their income went to that purpose. A section of 640 acres is divided into halves, quarters, half quarters, and quarter quarters; for example, the SW¼NW¼ sec. 10, T. 2 N., R. 5 E. would be the legal description of a certain 40 acres of land.

Signs and Symbols. In map making, certain conventional signs are used. Symbols have been adopted for mountains, rivers, lakes, coast lines, cities, boundaries, and other fea-

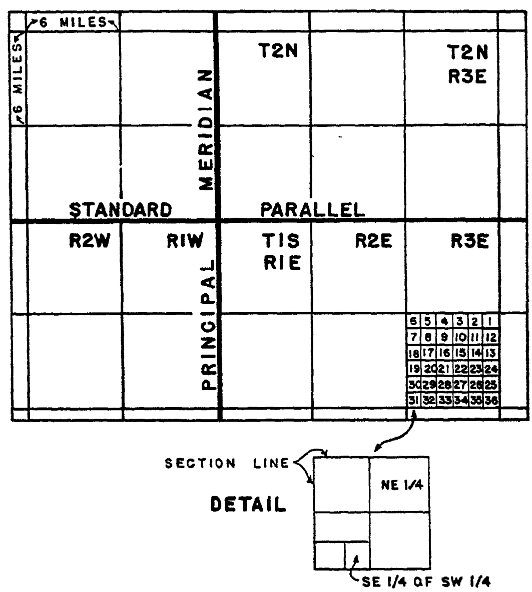

FIG. 16. Plan of survey for most of the public lands in the central and western United States. Ranges are aligned east and west of a principal meridian; townships are measured north and south of a standard parallel. Each six-mile-square township is divided into 36 sections of 640 acres each, and each section is subdivided into halves and quarters. (See detail of section.)

tures. If the map is of large scale, houses, roads, railroads, and other small features may be shown. The symbols chosen for a map depend on its purpose. For classroom use, maps need only the most important place names indicated in type that can be read across a schoolroom. Symbols for cities may be printed in red to make it easy to locate them and may be designated by circles, squares, or triangles to represent their proportionate populations. Dot maps, with the size and number of dots arranged in proportion to concentration of population or other data are useful in providing information at a glance. Sometimes gradations of colors or crosshatching are substituted for the dots. In general maps should be drawn as simply, legibly, accurately, and attractively as possible.

Methods of Showing Relief. Relief features are of special importance to the geographer, and various schemes have been devised for the indication of relief differences. These include black and white sketching, shading, hachures, and contours (lines connecting places of equal elevation above sea level). Another method uses different colors, ranging from green, representing land below 1,000 feet in elevation, through yellow and brown to red for areas above 10,000 feet. Sometimes shading and colors are used to show different types of land surfaces rather than actual elevations. Models may emphasize outstanding facts of relief quite clearly, but they are not easily portable. Models are generally more expensive than maps, and their use is restricted to display or class demonstration and other special purposes. Contour maps were chosen by the U.S. Geological Survey for the topographic sheets published by that bureau which show details of the relief features of the country.

Use of Maps. Maps may be used to show relationships as well as to provide needed facts of location. By a comparison of maps of population, relief, rainfall, temperature, mineral resources, natural vegetation, and economic use of land, facts and principles of geography can be made clear. Two maps may show coincidence of data through accident. When coincidence is noticed, a study must be made to determine whether this is accidental or whether correlations exist. For example, very definite relationships can be shown by comparing Fig. 139, of relief with Fig. 250 of world population. It will be noticed that the densely populated parts of the earth in the middle latitudes are lowlands and that mountains and high plateaus are avoided by men. On the contrary, in the tropics, highlands often support more people than adjacent lowlands because of a more invigorating and healthy climate than that which characterizes the lowlands. A comparison of population and rainfall maps (Fig. 47) will show that deserts where unreclaimed by irrigation support few people. Excessively rainy districts, unless relieved by a dry season, generally are thinly populated. Moderate rainfall without excessive heat or cold supplies more favorable living conditions, and the large populations are generally found in such regions. Important relationships between rainfall and natural vegetation can be shown by comparing Figs. 47 and 55.

Maps are used for a variety of purposes. For teaching the facts of economic or commercial geography, maps are drawn to show distribution of the mineral, agricultural, pastoral, or industrial resources by selecting colors, dots, or symbols proportionate to production or other suitable schemes. Routes of transportation and communication are best shown by maps that indicate location of highways, railroads, air lines, ocean steamship routes, telephone, telegraph, and cable lines. Sometimes highway maps or maps in railroad timetables are grotesquely distorted in order to emphasize the directness and other advantages of some particular route.

Collections of maps appearing in book form are particularly useful to the student. These are known as *atlases* and are important reference works when geographic facts are needed. A good atlas is indispensable, for it will provide the locations of places at a glance. It

should provide much more than that; and, in selecting an atlas for use in human geography, it is well to remember that economic data, precipitation, winds, relief, vegetation, trade routes, races, and similar information about the world generally are more important than political boundaries, county seats, or the locations of unimportant towns.

Maps assume special importance in military and naval operations, and special types are usually devised for this purpose. Small-scale military maps are called *planning maps* or charts, and on these the movements of entire armies and navies may be charted. More detailed tactical maps are necessary in order to carry on local maneuvers; on these, details of the relief, sources of good water supply, difficult river crossings, mountain passes, impenetrable swamps, and other hindrances to rapid movement of troops must be shown with great care. Usually these maps have "overlays" of transparent paper or plastic substances which fit over the maps and provide essential last-minute information for actual operations in the field. Special naval maps are issued, showing the condition of coast lines, the depth and character of anchorages, dangerous shoals, and other features of extreme importance to naval operations in wartime. Maps of airways, with principal natural features, high mountain ranges, beacons, and radio beams are a necessity in both war and peace. Most military and airways maps are prepared and issued by government agencies. Other maps that originate with the government include maps of soil conditions and daily weather data, maps of national forests and national parks, and a wide variety of miscellaneous maps issued for special purposes.

Problems

1. How do the length and direction of one's shadow change during the day in this latitude?
2. How do the length and direction of one's shadow change during the year in this latitude?
3. What is the maximum length of the daylight period at the equator?
4. What is the most desirable quality of a map. from the geographer's viewpoint?
5. What map projection would you select for showing (*a*) the relation between longitude and time; (*b*) United States; (*c*) navigation at sea; (*d*) distribution of the world's vegetation zones; (*e*) the world to a first-grade pupil?
6. How many times each year can a man at 0° latitude see the sun directly overhead?
7. In your present latitude, how many times each year will you see the sun overhead?
8. Distinguish between earth rotation and earth revolution.
9. What places on the earth have the longest period of continuous darkness each year?
10. Why does the radiation reaching the earth from the sun vary during the year?
11. Which is more effective in heating the atmosphere: (*a*) a high angle of the sun at noon or (*b*) long duration of solar radiation?
12. If, on December 21, an observer sees the noonday sun at an angle 70 degrees south of his zenith, find his latitude.
13. On June 21, at noon, a ship's captain sees the sun at an angle 70 degrees above the north horizon. At the same time his chronometer reads 3 P.M. Determine his latitude and his longitude.
14. What is the latitude of the equator?
15. If the earth's axis were not inclined, how long would our daylight periods be?
16. What is the total extent of latitude in degrees which may experience the vertical rays of the sun throughout the year at the different seasons?
17. How does artificial illumination affect our daily activities?
18. What are the advantages of the usual custom of sleeping at night and working during the daylight hours?
19. Why is leap year necessary in our present calendar?
20. What would be the advantages and disadvantages of a calendar having 13 months of 4 weeks each?
21. How is your age related to the earth's revolution?

22. How many trips have you made around the sun?
23. Under what conditions could you expect the sun to shine in a north window?
24. What would be the effect of an increase or decrease of the rate of (*a*) earth rotation and (*b*) earth revolution upon the length of day or year?
25. What would be the latitude of the Tropic of Cancer if the earth's axis were tilted 40 degrees from the vertical position?
26. At what point would latitude 0° and longitude 0° be located?
27. At what points would latitude 90° and longitude 0° be located?
28. Why is the international date line necessary?
29. How many standard time zones are there in the United States?

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CHAPTER 3: *The Atmosphere*

Air affects man in many ways, since people breathe, move, live, and die in this all-pervading medium. Our atmosphere, consisting of a mixture of gases, forms the gaseous part of the earth and is as much a part of the earth as the water (hydrosphere) and solid rock (lithosphere). Physical changes in the air cause variations in weather and climate that profoundly affect human beings and are basic to an understanding of geography.

Extent of the Atmosphere. Air seems light, yet it is estimated that the air in the world weighs 11,850,000,000,000,000,000 pounds. This atmosphere extends upward from the surface of the solid earth for many hundreds of miles, although its exact limits are unknown. Half of it lies below the height of 19,000 feet. At high altitudes the air is extremely rarefied. Even in the tropics no human beings live permanently more than 3 miles above sea level. Airplanes have flown over 10 miles above the earth and special balloons have carried men to altitudes of nearly 14 miles, but at such elevations man requires oxygen tanks to retain consciousness and life. That the earth's atmosphere extends outward in a rarefied condition higher than any balloon has risen is proved by the appearance of "shooting stars" at an average height of 80 miles. These meteors travel so fast they become heated to incandescence by their passage through the air and generally disappear from 30 to 60 miles above the earth's surface. Most meteors are small objects like a bit of gravel or fragment of iron and are consumed in the air, but the larger ones may reach the ground and are then called *meteorites*. Experiments with rockets equipped with instruments also increase our knowledge of the upper air (Fig. 17).

Pure dry air near the earth's surface consists chiefly of two gases, oxygen (21 per cent by volume or 23 per cent by weight) and nitrogen (78 per cent by volume or 76 per cent by weight). The balance of 1 per cent is divided among several gases, including argon, helium, carbon dioxide, neon, and water vapor (water in a gaseous state). The lower air also contains water vapor (from a trace to 5 per cent) and dust in variable amounts. Somewhere in the upper air it is possible that the percentages of the lighter gases (hydrogen and helium, for example) increase and that those of the heavier gases decrease under the influence of gravity.

The percentage of the different atmospheric gases varies slightly at different parts of the earth. Over industrial cities, carbon dioxide may increase from its ordinary proportion of three or four parts in 10,000 to more than double that figure. Air over oceans is freer of dust impurities and usually has a higher water-vapor content than air above land.

Uses of the Constituents of Air. The differ ent constituents of the air have varied uses and effects. The oxygen and nitrogen that make up the bulk of the lower air account for most of its pressure or weight and the force of the wind, and they furnish needed support for aircraft. Without oxygen, all animal life would perish and man could not exist on the earth in his present form. Oxygen dissolved in ocean and inland waters is required for the support of fish life, and air in the soil is of benefit to the growth of plants. Combustion is merely the chemical union of oxygen and other elements. Nitrogen, inert under ordinary conditions, dilutes the oxygen and slows up the oxidation process. In addition, certain bacteria and other agencies remove small amounts of nitrogen from the air and fix the substance in the soil where it is available for plants. The condensation of water vapor makes clouds, fog, dew, and frost. When forms of condensation progress until gravity acts upon them, they fall to the earth

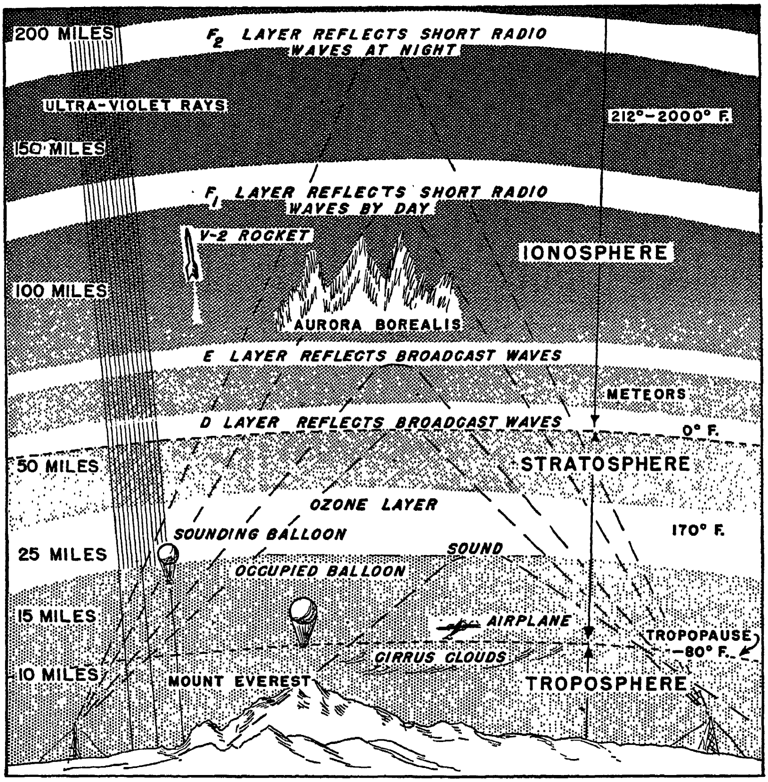

FIG. 17. The conditions of the earth's atmosphere, according to recent theories. (*Used by permission of James Lewicki and The New York Times.*)

as precipitation in the form of rain, snow, hail, and sleet.

Carbon dioxide is taken from the air to support plant life and is liberated into the air by the breathing of animals, burning of coal, decay of organic matter, and other forms of oxidation. Carbon dioxide and water vapor permit most of the radiant energy from the sun to reach the ground but act as a thermal blanket to retain much of the heat radiated from the earth itself. Particles of dust influence sunrise and sunset colors, produce the phenomenon of twilight, help form the thermal blanket, and serve as nuclei for the formation of raindrops.

Layers of the Atmosphere. Three layers of the atmosphere have been named troposphere, stratosphere, and ionosphere. The name *troposphere* has been applied to the lower layer of the atmosphere, extending to a height of from 5 to 10 miles. In the troposphere the temperature decreases at the *lapse rate* of about 3.5 degrees per thousand feet of elevation. The troposphere was so named because of this regular change in temperature. Variations of temperature, wind direction, cloudiness, rainfall, relative humidity, and other phenomena accompany the storms common in the troposphere. All the changes associated with day-by-day variations in the weather of mid-latitudes are limited to the troposphere. This lowest layer of air contains the clouds, practically all the water vapor, and 90 per cent of the total mass of air. Most of the carbon dioxide remains in the troposphere, its relative weight making its upward diffusion difficult.

The second layer of the air is called the *stratosphere* because it has a nearly uniform temperature and freedom from storms. At an

elevation of about 10 miles above the equator, 7 miles above the central United States, and 5 miles above the pole, the air temperature remains constantly cold. The upper limit of the troposphere is named the *tropopause,* since the temperature no longer decreases regularly above that point. Here the lapse rate is close to zero, probably because of a balance between absorption and radiation of heat. The stratosphere continues up to elevations of about 35 to 50 miles. At the top of the stratosphere the atmospheric pressure is less than ½ millimeter compared with 760 millimeters of mercury at sea level. This means that less than 1/1,500 of the atmosphere lies above the stratosphere. No propeller plane or balloon can hope to soar to such heights, since the air density would not furnish adequate support. Only some form of rocket or jet plane, propelled by the reaction from explosions, could navigate the dizzy heights of the upper stratosphere.

The *ionosphere* forms the thin outermost layer of the atmosphere. The ionosphere became known because of its effect on radio waves and the occurrence of the northern lights within this zone. Radio waves progressing from their source toward outer space are apparently reflected back to earth by this high conductive ionized layer. The height of the reflection layer varies; the zone at about 70 miles, called the Kennelly-Heaviside (E) layer, reflects the radio waves between 300 and 400 meters long; and the Appleton (F-1) layer, about 140 miles in elevation, reflects the short radio waves. The reflecting layers may vary considerably at different hours of the day or night. The Heaviside layer is usually lower in the winter and at night, which makes for better radio reception. Sometimes the reflected radio waves miss certain areas, creating "blind spots" for the reception from particular broadcasting stations. Some of the shorter radio waves may pass out through the ionosphere into outer space and not be reflected at all.

Atmospheric Phenomena. Many curious occurrences of interest and some of human importance can be noticed in the atmosphere. Not only does the reflection from different layers of the atmosphere affect radio waves, but the light rays from the sun and other stars are also affected. Rays of differing lengths may pass through, or be impeded by, certain substances. Glass transmits most visible rays of light but is nearly opaque to infrared rays. On the other hand dust and waterdrops in the air interfere with transmission of ordinary light rays and make photography and sight difficult, while photographs taken through haze by infrared light are sharp and clear (Fig. 18). A fog would not be a handicap to travel by airplane or automobile if operators could see with infrared light.

Human eyes and bodies have become adjusted to the usual solar illumination. On mountaintops skin may be sunburned in cool weather by exposure to ultraviolet rays, which readily penetrate the thin atmosphere. In the tropics the skin develops more pigment for protection against strong solar radiation. Ozone, a form of oxygen containing three atoms to a molecule instead of the usual two, exists in greater abundance in the stratosphere than in the lower air. This blanket of ozone reduces the intensity of ultraviolet light reaching the earth's surface (Fig. 17). Most organisms on the earth would be destroyed if exposed for any length of time to direct ultraviolet rays, yet some of this radiation is desirable since it seems to furnish the body with vitamin D, required for proper growth. As human beings we have become adjusted to the usual amount of ultraviolet light. Much more would kill us and less would harm us.

The light-blue color of our sky results from scattering of light by dust and water droplets. With increasing elevation and resulting freedom from impurities, the sky becomes darker blue, and then a deep violet, many times darker than at the earth's surface. This turns finally to a violet-gray or black-violet. Toward the upper limit of the atmosphere the sky would appear black.

Various phenomena result from differences in temperature and the moisture content of

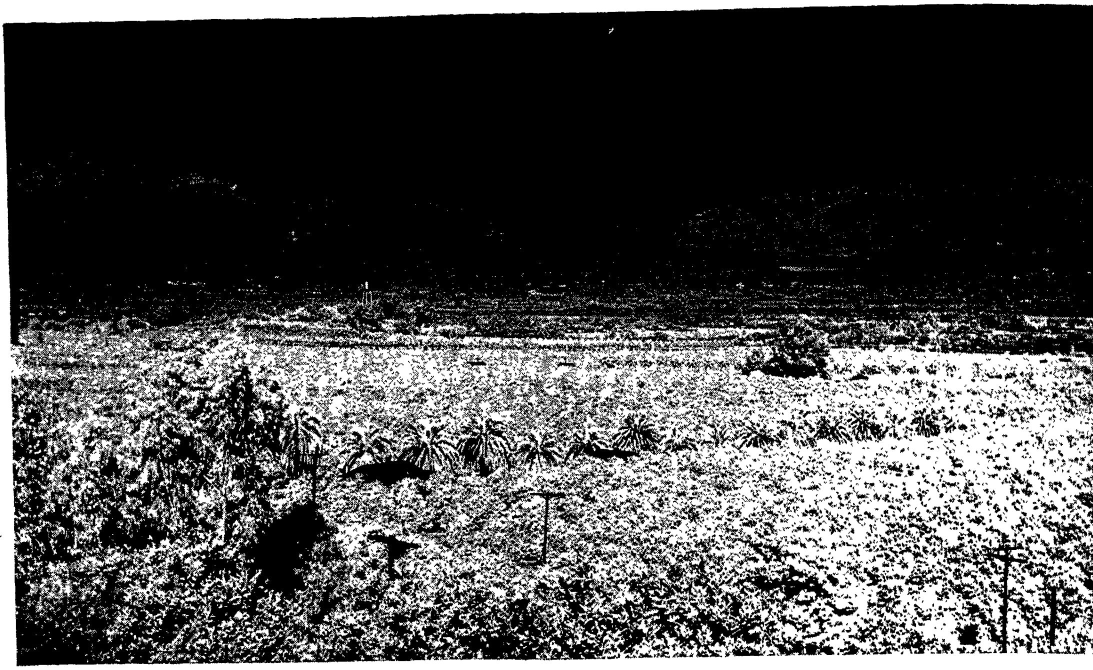

FIG. 18. Infrared photograph looking northwest toward the lower end of Cajon Pass in southern California. The San Gabriel Mountains appear at the left, and the San Bernardino Mountains at the right are at a distance of about 25 miles. Citrus groves in the foreground register white on infrared photographic film. (*Photograph courtesy of Robert Pease.*)

the air. For example, the rainbow appears when the sun's rays are refracted (bent) by passing through raindrops. The mirage occurs on hot clear days as the result of reflection and refraction of rays of light on layers of air at different temperatures. At sunset the sun's rays are so bent by refraction that the sun remains visible for a short time when it actually is below the horizon.

Northern lights extend from 50 to 600 miles into the atmosphere above the earth's surface. These peculiar arcs, curtains, and streamers of light in polar regions are called *aurora borealis* and *aurora australis.* They seem to be the result of electrical disturbances in the upper atmosphere which are associated with discharges of radiant energy (electrified particles) from the sun during periods of sunspot activity. It is believed that molecules of air become luminous because of bombardment by electrified particles hurled outward from the sun. The aurora colors are those made by oxygen and nitrogen, which suggests that the upper air consists of the same gases as the lower air rather than the light gases helium and hydrogen. Proof of their electrical character is that auroras increase in frequency toward the north and south magnetic poles rather than toward the geographic poles.

Insolation. Practically all energy received by the earth comes from the sun. The earth intercepts only one two-billionth of the sun's radiation; that small part which would fall on a disk 8,000 miles in diameter, situated on a sphere of 93 million miles radius. However, this small fraction of the solar radiation furnishes all the energy required for biological and physical activities on our globe.

The amount of insolation received at a particular place on the earth depends mainly upon the length of day, directness of the sun's rays, and clearness of the atmosphere. The revolution of the earth around the sun and the inclination of the earth's axis cause changes in the length of day and directness

of the sun's rays. These are the chief causes for differences in distribution of insolation on the earth, as previously noted. In addition, the condition of the atmosphere, its thickness, clouds, humidity, and dust, will cause changes in the radiant energy received on the earth's surface (Fig. 19).

Insolation retained or absorbed by the earth depends on conditions both in the atmosphere and on the earth. The relief, color, nature of surface, and other things determine relative amounts of absorption and reflection of light and heat from the earth's surface; and, as the condition of the atmosphere varies, so does its influence on the reception of solar radiation. Atmospheric changes also affect the radiation of heat from the earth. After insolation has been absorbed it may be widely distributed by winds and ocean currents, making earth temperatures more equable.

Distribution of Insolation. Insolation is distributed by physical processes called *conduction, convection,* and *radiation.* Neither water nor solid earth is a good conductor of heat, and a few feet below the surface of either the temperature is unaffected by conduction. Thus a deep well will furnish water at a uniform temperature throughout the year. Convection results from the contraction of fluids on being cooled and their expansion on heating. Thus cooled water or air sinks and the warmer water or air is thereby forced to rise, forming a circulation or convection current. Convection is a fundamental cause of the circulation of the atmosphere and of ocean currents.

Radiation is a transfer of heat by wave motion. The sun's energy arrives on earth by this process, but after absorption by the ground some of the heat it produces is again radiated into the atmosphere. Such radiations have long wave lengths and do not pass through the layers of atmosphere readily. The air is heated mainly by these radiations of the earth rather than directly from the sun. Both air and water can be made to rise by the application of heat. When air rises, however, it expands, the molecules that compose it are farther apart and do not strike each other so frequently, and its temperature falls. In a way, since air rises when heated and the rising causes cooling by expansion, one could almost say that air should be heated if it is to be cooled. The molecules of descending air are subjected to increased pressure, which causes the molecules to come closer together and collide more frequently, thereby producing heat, which causes the temperature of the air to increase.

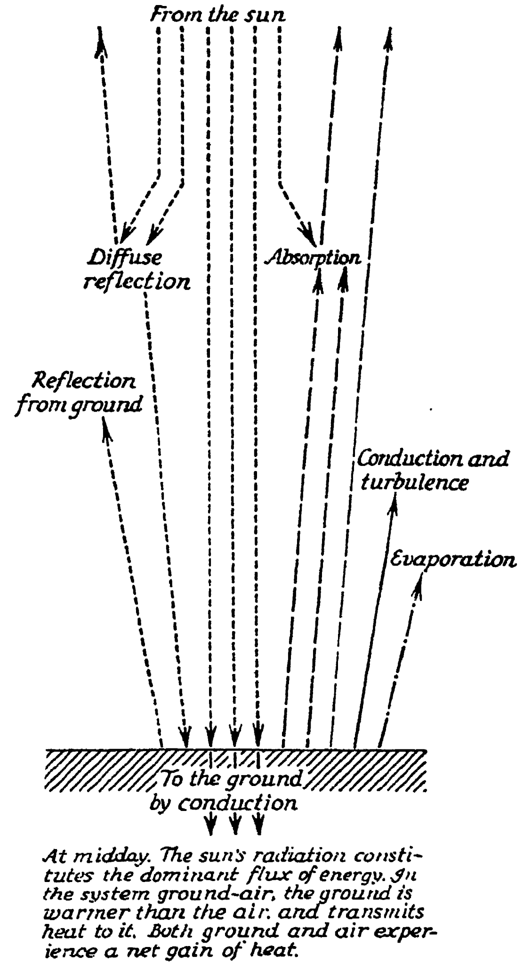

FIG. 19. Exchange of energy between earth's atmosphere and the ground at midday. (*Based on a drawing by R. Geiger. Courtesy of John B. Leighly.*)

World Temperatures Shown by Isotherms. Distribution of temperature is shown on maps

by *isotherms,* which are lines connecting places having equal temperatures. In general, since insolation decreases poleward, isotherms would be expected to parallel the equator. Study of the world isothermal maps for January and July (Figs. 20 and 21) shows, however, that many isotherms vary considerably from their expected east-west courses, especially in the Northern Hemisphere, in which land areas are large. In January the isotherms of 40°F. and lower are closer to the equator over the continents than over the oceans, and the coldest spots on earth are in the northern interior of continents, notably Siberia. In July the reverse of this condition holds true, and the isotherms diverge farther from the equator on passing from the oceans to the continents. The interiors of continents, like the northern part of Africa, southern Asia, and the southwestern United States, have the highest average temperatures, while oceans in the same latitudes are many degrees cooler. South of the equator there is less variation in the courses of the isotherms, primarily because this is the water hemisphere. It is apparent that near the equator there is little change in position of the isotherms throughout the year, although the location of the heat equator (the line connecting places of highest temperatures) shifts well north of the geographical equator in July.

In contrast to equatorial regions, the mid-latitudes and high latitudes show large seasonal ranges of temperature, especially in the continental interiors. For example, the seasonal range in North Dakota amounts to 60 or 70°F. and that in northeastern Siberia to over 100°F. Maximum and minimum temperatures of middle and high latitudes lag behind the insolation because summer temperatures continue to rise as long as receipt of solar energy exceeds loss by radiation. The hottest time of year in the Northern Hemisphere in mid-latitudes is usually July and early August. In a similar way January is generally colder than December, since it takes the earth time to cool off after the heat of summer.

It should be noted that the locations of maximum temperatures are not at the equator but from 20 to 40 degrees from that line, usually in desert regions where clouds seldom interfere with the passage of solar energy. In these latitudes in summer the sun's rays are nearly vertical at noon and the length of day is longer than at the equator.

Land is heated faster than water because (1) the relative rate of heating (specific heat) of water is much higher than that of rock and soil, and the temperature of a rock can therefore be raised several degrees with the same heat needed to increase the temperature of an equal weight of water 1°; (2) water is mobile, and heated water is distributed by convection and other currents; and (3) water reflects considerable insolation, although some land surfaces, especially snow and bare sand, may reflect more rays than water. The seasonal lag of temperature is more noticeable on windward coasts and in insular locations than in the interiors of continents, because large bodies of water take longer to heat and cool than do the land masses. This gives rise to the expression "marine influence" in referring to coastal weather conditions. Thus February is as cold as January and August is as warm as July along windward coasts in the northern middle latitudes.

The Barometer. The density of the air (weight per unit volume) varies widely in different parts of the atmosphere, and the barometer was designed to measure the air pressure resulting from these differences in weight. It consists of a glass tube over 30 inches long sealed at one end, filled with mercury, and inverted in a cistern of mercury (Fig. 23). A vacuum exists above the mercury in the tube. The weight of the air presses upon the mercury in the open cistern and balances the column of mercury in the tube. Slight variations in the height of the mercury indicate changes in air pressure. When the atmospheric pressure increases, the mercury is forced higher in the tube; but, when the air pressure decreases, the mercury column falls, thus giving a quantitative measure of

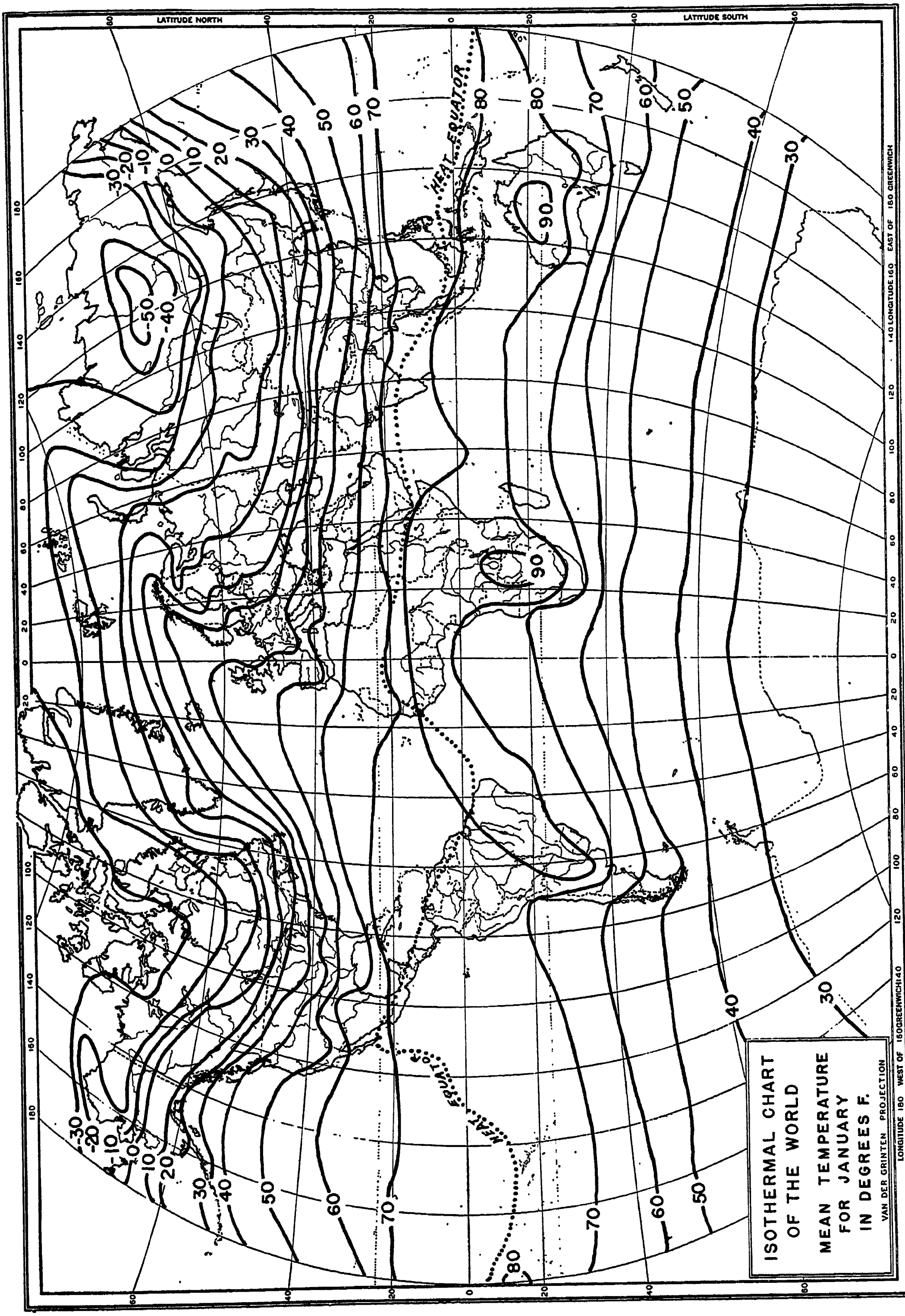

FIG. 20. Isothermal chart of the world showing mean temperature for January reduced to sea level. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

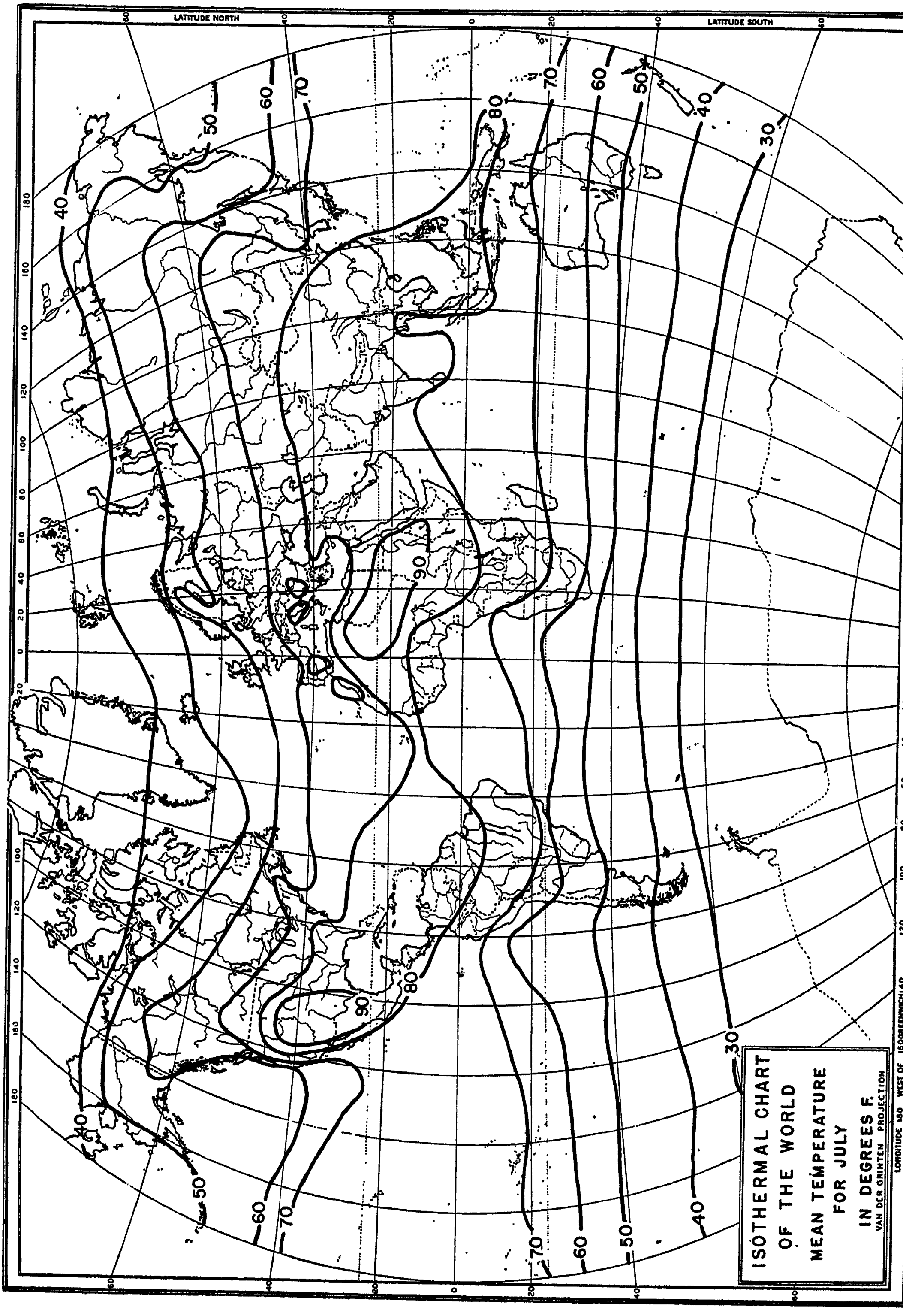

FIG. 21. Isothermal chart of the world showing mean temperature for July reduced to sea level. *(Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.)*

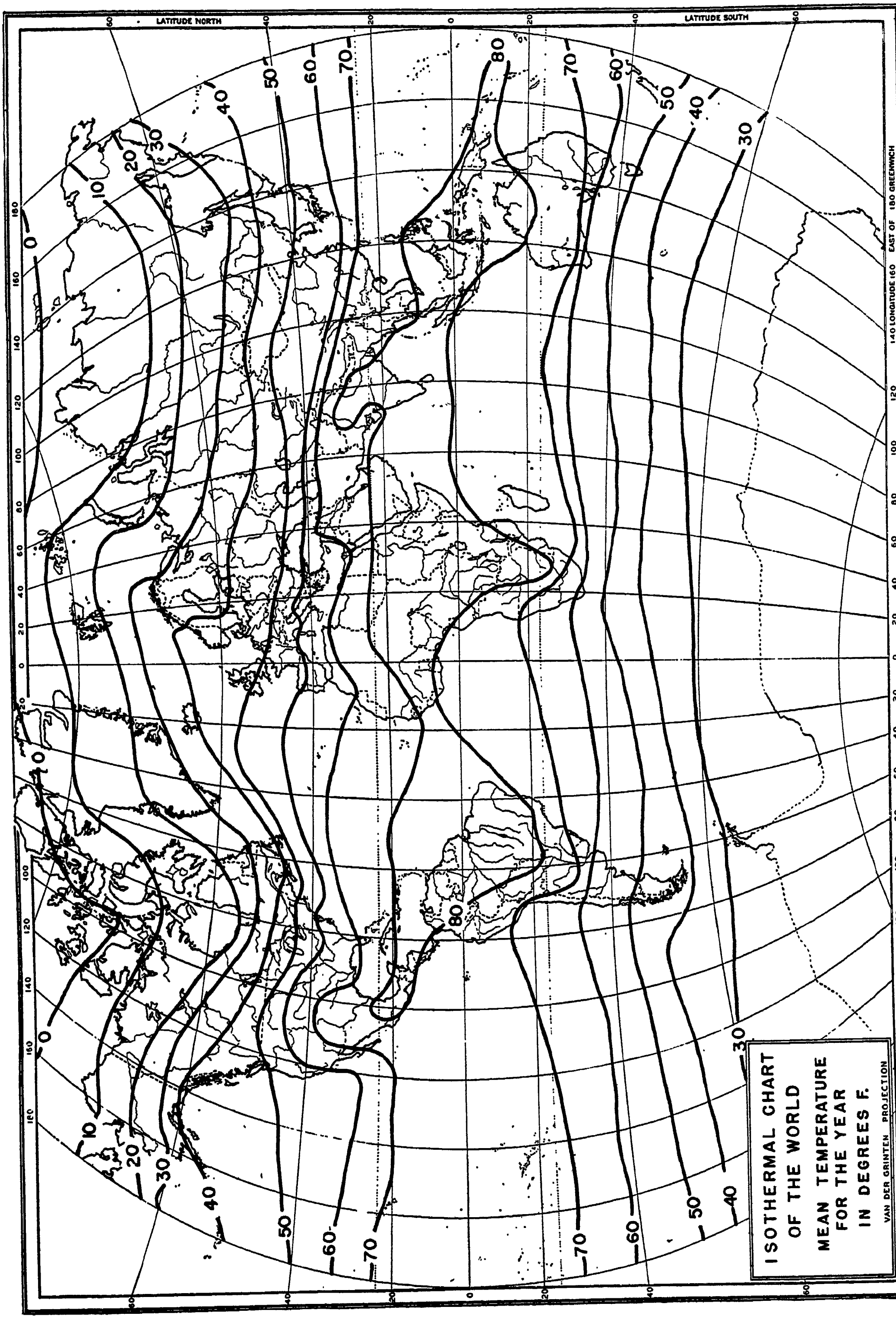

FIG. 22. Isothermal chart of the world showing mean temperature for the year reduced to sea level. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

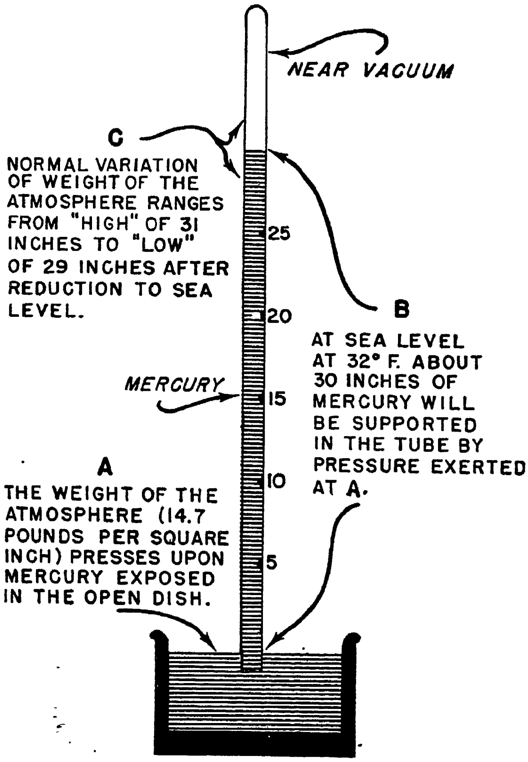

FIG. 23. The principle of the mercurial barometer.

that pressure. At sea level, average atmospheric pressure on the barometer is 76 cm. of mercury, equivalent to a column of mercury about 30 inches high. Mercury is used because it is a heavy liquid and does not freeze at ordinary temperatures. Since 1940 the weather maps of the United States have shown pressure in *millibars.* By definition a millibar is a force equal to 1,000 dynes per square centimeter. (The dyne is the force that will impart a velocity of 1 cm. per second to a mass of 1 gram in 1 second.) Sea-level pressure of 76 cm., equal to 29.92 inches of mercury, is equivalent to 1,013.2 millibars. Pressures above that of adjacent regions are called "high," and those below, "low."

Less air exists above elevations higher than sea level than at sea level, and barometer readings are correspondingly lower by approximately one-thirtieth for each 900 feet of ascent. Obviously elevations can be determined with a barometer. For that purpose a portable instrument called the *aneroid barometer* (Fig. 24) is used in which readings are made by a pointer attached to a hollow coil of assembled disks and chambers from which the air has been exhausted. One end of the coil is exposed to the air, and the pointer moves with changing air pressure. The aneroid is not so accurate as the mercurial barometer, but it is compact, light, and portable and hence is often the instrument used on airplanes to show their elevations. When thus used it is known as an *altimeter.*

World Distribution of Pressure by Isobars. Differences in pressure on the earth's surface are the direct cause of the winds, and they affect the temperature, rainfall, and other weather conditions. An *isobar* is a line drawn on a map connecting places of equal pressure. On isobaric maps pressures are corrected for elevation and reduced to sea-level conditions so that they may be compared.

In the isobaric map for January (Fig. 25) it will be noted that pressures are high over the Northern Hemisphere continents. The isothermal map for January (Fig. 20) shows that the high pressure coincides with low temperatures. The air in these continental "highs"

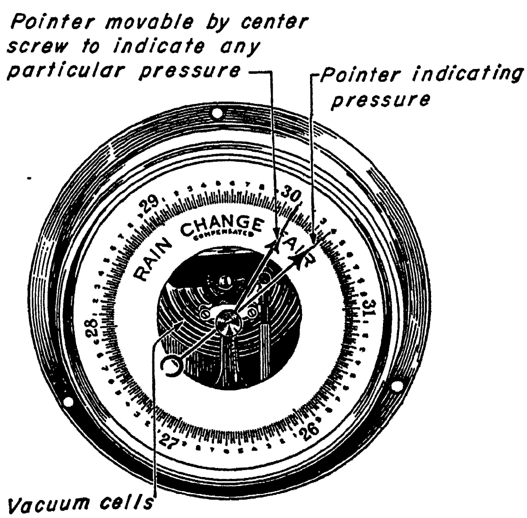

FIG. 24. The aneroid barometer. The figure 30 indicates normal atmospheric pressure at sea level at 32°F. The illustration indicates pressure greater than 30 inches (30.4); consequently the air pressure at the time of the barometer reading was "high."

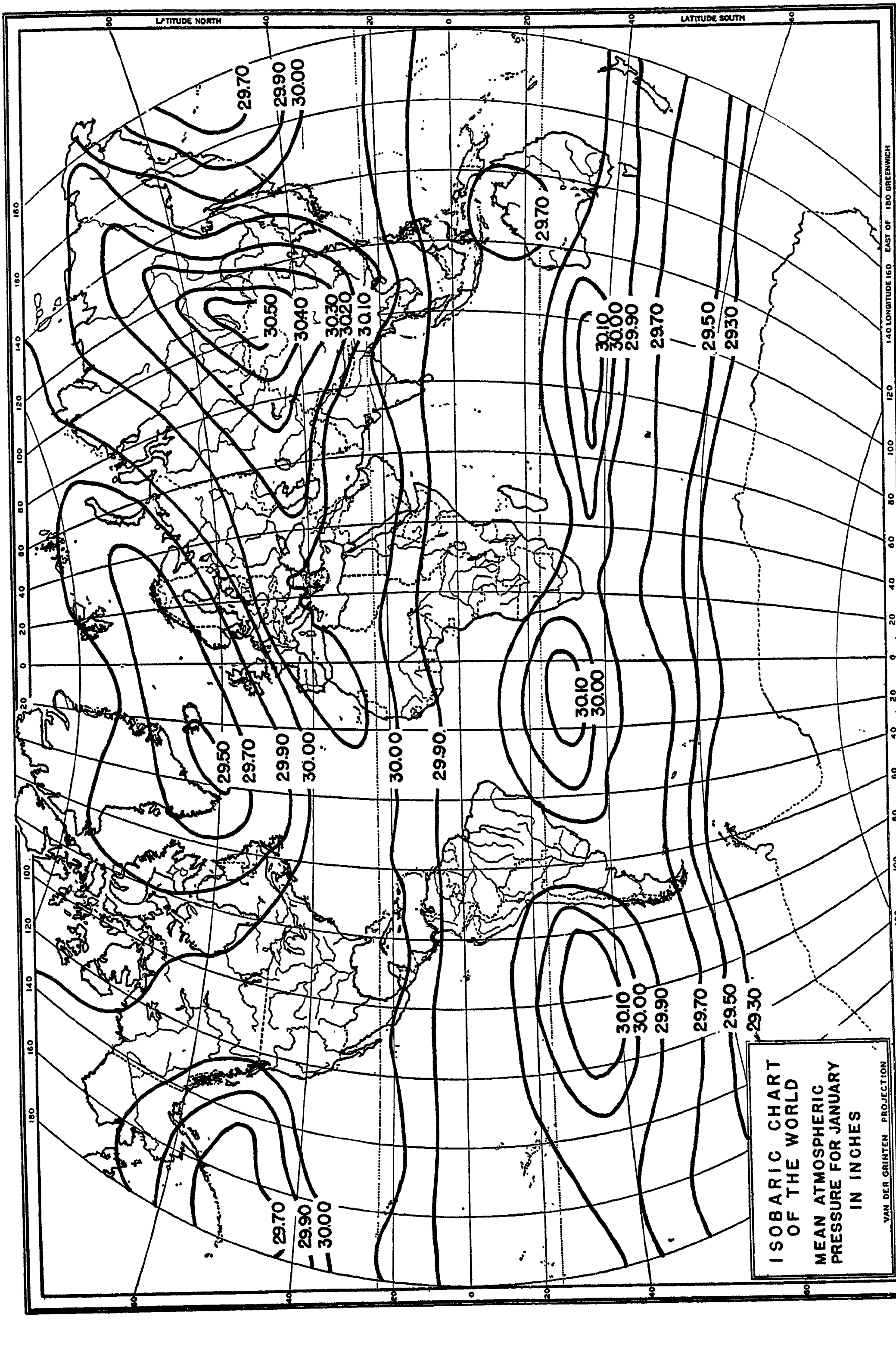

FIG. 25. Isobaric chart of the world showing mean atmospheric pressure for January reduced to sea level. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

in winter is typically dry and cold. Sunshine is common during the days, but the snow cover on the land reflects much of the insolation and the clear nights favor rapid loss of heat by radiation. Winds tend to move outward from the center of the "high," with moderate velocity toward the surrounding oceans where the air pressure is lower. Well-defined "lows," or pressure troughs, occupy the North Atlantic (Icelandic low) and North Pacific (Aleutian low). The subtropical highs, from which the northeast trade winds blow, center over the oceans near 25°N. latitude. Low pressures along the heat equator are somewhat south of the geographic equator—most noticeably over the southern continents. A well-defined belt of high pressure occurs from 25° to 40°S. latitude. On the map for July (Fig. 26) this belt is displaced toward the equator. Less difference occurs in the Southern Hemisphere between January and July than in the Northern Hemisphere because the preponderance of water masses equalizes temperatures and lessens pressure differences between land and water during the seasons of winter and summer, as compared with the Northern (or land) Hemisphere.

Comparison of isothermal and isobaric maps for the same season of the year shows such coincidence between high temperatures and low pressures and between low temperatures and high pressures that it seems certain that such distribution is the major factor in determining the world pressures and circulation of the winds which result from pressure differences (Chap. 4 and Fig. 36). Air settles in cold regions, thereby increasing the surface pressure there and promoting outward-flowing surface winds. In warm regions air expands, and above the ground may flow away sideways reducing surface pressure.

The July isobaric map (Fig. 26) shows well-defined low-pressure areas in southern Asia and mid-United States toward which winds blow from the higher pressures over the oceans. Two well-defined high-pressure areas in the subtropics are named the Azores high in the Atlantic and the Pacific high in the North Pacific. When these oceanic highs spread over portions of the continents, drought is the result. This happens regularly in summer in the Pacific Northwest and occasionally in the southeastern United States. Usually, however, the Azores high stands off the coast and causes moist air masses to move onshore in the southeastern United States, which as a result receives abundant summer rains, most often of a convectional origin. Neither the Aleutian nor the Icelandic low is much in evidence in summer (July). In the Southern Hemisphere, because ocean predominates, changes in pressure between July and January are small compared with changes in the areas north of the equator.

Water in the Air. Water vapor is the most variable gaseous constituent of the air. The quantity of water vapor in the air depends on the temperature, the amount of water available for evaporation, and other conditions. In general, the higher the air temperature the greater the amount of water that can exist in the vapor form in any given volume of air. Much heat is required to vaporize water, that is, to change its state from water to gas without any change in the temperature. This *latent heat of vaporization*, as it is called, amounts to 5.4 times the heat required to raise the temperature of water from the freezing point to the boiling point. The evaporation of water is an effective way of cooling the air, as is demonstrated by its use in some air-conditioning processes, by the coolness that may follow a shower, or by the sprinkling that cools a house and yard. When water vapor condenses, as much heat is liberated as was absorbed by the evaporation of the same moisture. In order to produce condensation it is therefore necessary to cool the air.

Relative Humidity. When a given volume of air contains the maximum quantity of moisture at a certain temperature it is said to be *saturated*. The term humidity refers to the water vapor in the air. *Absolute humidity* is the total weight of water in a given volume of air. *Relative humidity,* which is always

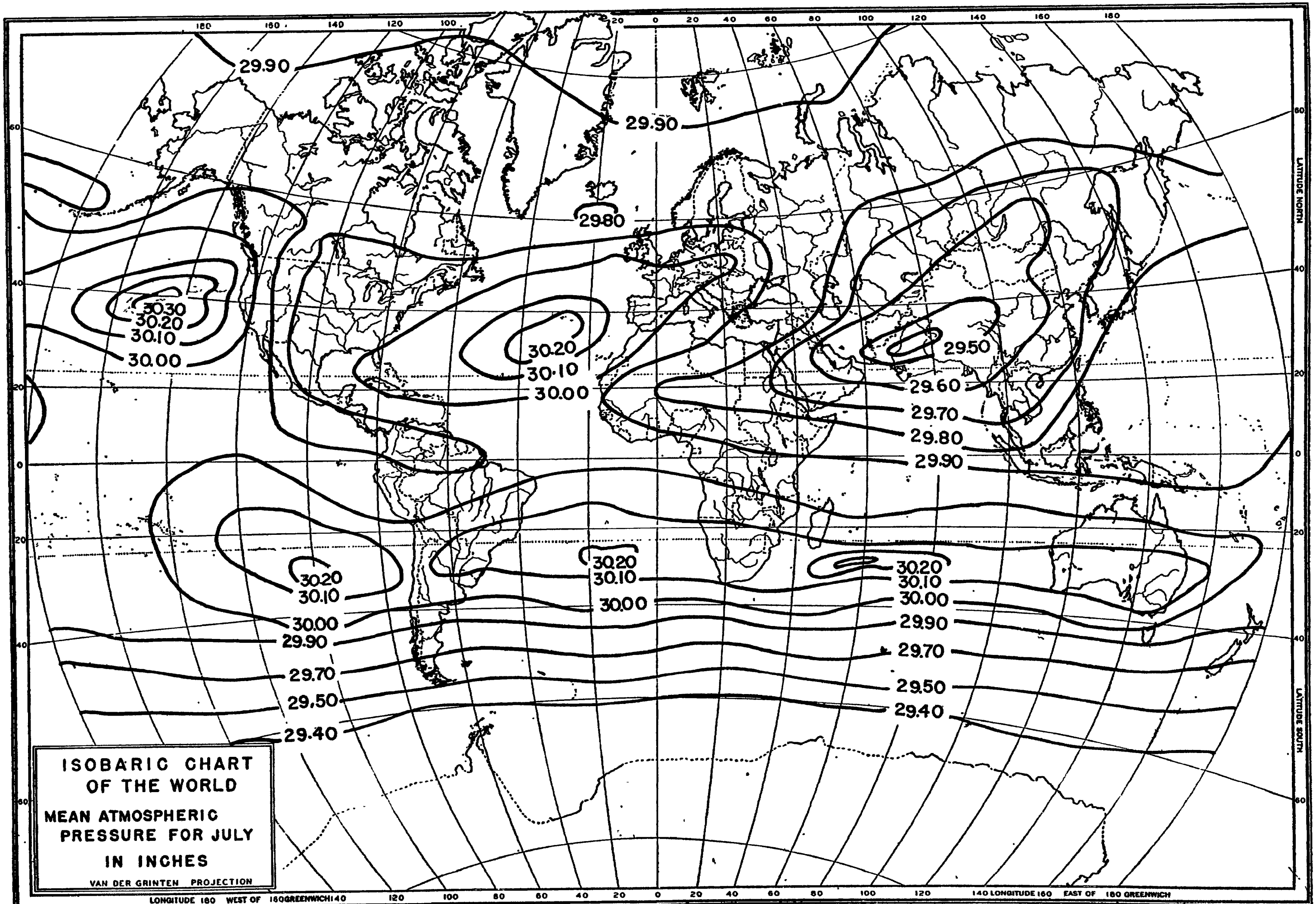

FIG. 26. Isobaric chart of the world showing mean atmospheric pressure for July reduced to sea level. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

expressed as a ratio or percentage, represents the amount of water vapor actually in the air (absolute humidity) compared with the amount the same volume of air could contain if saturated at the same temperature. Thus 1 cubic foot of air contains 5.7 grains of water vapor when saturated at a temperature of 60°F. If experiment shows that the air actually contains 1.9 grains of water per cubic foot, the relative humidity would be one-third, or 33 per cent. Thus the term relative humidity refers to the ratio between the amount of water vapor in a certain volume of air and the maximum amount that might exist without condensation.

Another way of determining relative humidity is based on the temperatures shown in two thermometers, one of which has a dry bulb, while the bulb of the other is kept wet by cloth immersed in water. The wet-bulb thermometer has a lower temperature because of cooling by evaporation. The relative humidity is calculated from Table 1.

TABLE 1. RELATIVE HUMIDITY OF THE AIR IN PER CENT AT VARYING TEMPERATURES

Dry-bulb thermometer, °F.	*Depression of wet-bulb thermometer, °F.*								
	2	4	6	8	10	12	14	16	18
40	83	68	52	37	22	7			
50	87	74	61	49	38	27	16	5	
60	89	78	68	58	48	39	30	21	13
65	90	80	70	61	52	44	35	27	20
70	90	81	72	64	55	48	40	33	25
75	91	82	74	66	58	51	44	37	30
80	91	83	75	68	61	54	47	41	35

First the depression in degrees between the wet- and dry-bulb thermometers is noted. If we assume the depression is 8°, we read down that column to the temperature of the dry-bulb thermometer, which we assume is 70°, and the relative humidity is given as 64 per cent. As another example, if the dry-bulb thermometer reads 65°F. and the wet-bulb thermometer reads 55°F., the depression would be 10°, and the relative humidity by the table would be 52 per cent.

If air is completely saturated and then cooled, less water can exist in the vapor form and condensation begins. Contrariwise, when the temperature increases, a given volume of air can contain more water vapor. Thus relative humidity drops with a rise in temperature, without any change in the actual quantity of vapor. A cold room seems damp, for example, because of high relative humidity; but when the room is heated it seems dry because the relative humidity drops. If air is cooled enough, even though the quantity of vapor is small, the relative humidity reaches its maximum and condensation begins. The temperature at which this occurs is called the *dew point*. In the open, clouds form when rising air currents have cooled to the dew point by expansion. When moisture collects on the outside of a glass of ice water it indicates that the cold surface has lowered the temperature of the surrounding air below the dew point.

The relative humidity of air has important effects. Low relative humidity in houses dries out wood and glue, causing furniture to loosen and crack. At times of low relative humidity the air evaporates moisture from the body and causes the skin to become rough and cracked. Ointments or grease rubbed on the skin help to prevent such evaporation. When air has a low humidity it seeks moisture everywhere. For example, in the woods the duff on the forest floor dries out and makes a dangerous fire hazard. Garden plants and field crops may lose so much moisture during hot dry weather that their growth is stopped, and if these conditions last too long the plants die. Cotton fibers become brittle and fuzzy in dry air. Cotton mills formerly were located preferably in regions of damp air, but now the humidity of the air in cotton mills is artificially controlled, permitting the weaving of quality cloth under all weather conditions. Tobacco becomes dry and brittle during days

of low relative humidity. Leaf tobacco is packed for shipment during damp weather when the leaves have absorbed moisture and will not break when pressed together. Coffee roasts more quickly on dry days than during damp weather. High relative humidity nevertheless usually means discomfort, for air that is nearly saturated cannot rapidly evaporate perspiration from the skin resulting in a diminution in rate of removal of heat going off as latent heat used in evaporating water.

When water is evaporated a large amount of heat is used in the process, as described on page 40. Condensation of vapor to the liquid state demands that a quantity of heat be liberated equal in amount to that required for its evaporation in the first place. The absolute humidity rapidly increases with rising temperatures, and a cubic foot of air when saturated at 100°F. contains more than three times the quantity of water vapor that would be contained in saturated air at 60°F. Similarly the air at 60° contains exactly three times as much weight of water vapor when saturated as it would at 30°F. When air has a high relative humidity and is near the saturation point, a small amount of cooling will bring about condensation. The cooling of air that is saturated at a high temperature will cause much more rain than the cooling of saturated air at a low temperature, since the absolute humidity is so much higher.

Condensation of Moisture. The condensation of moisture depends upon the relative humidity of the air and the amount of cooling to which it is subjected. Condensation produces drops of liquid that compose the raindrops, dew, fog, and lower summer clouds. Although clouds of water droplets may exist with a temperature well below freezing, a temperature of the dew point below 32°F. at the time of condensation is required for the formation of frost crystals and snowflakes. An important automatic cause for cooling of the air, called *adiabatic,* results from the expansion of air during upward movement (1) over mountain barriers, (2) over masses of cold heavy air, or (3) in any rising air current. Adiabatic cooling is the most common cause of rain, fogs, and clouds. Air may also be cooled by the mixing of warm and cold air currents and by radiation and conduction of heat, bringing about fogs, dew, and frost through condensation.

Dew and Frost. Dew and frost do not "fall" but condense on cool surfaces from the surrounding air. Some moisture for dew also comes from the ground by capillarity and from transpiration of plants. A calm, clear, cool night favors dew formation, since surfaces lose their heat by radiation in clear night air, but the presence of wind causes the dew to be reevaporated in fresh dry air. On cloudy nights radiation is at a minimum and the dew point on the surfaces of objects may not be reached. Frost forms when air temperatures have fallen below the freezing point. Vegetation may be damaged by the freezing of water within the cells of a plant, which may rupture tissues and kill the plant, even when wind or some other factor prevents the formation of visible frost crystals. Such destruction of vegetation by freezing is sometimes called "black frost." Citrus growers who have to fight frost conditions in their groves particularly fear heavy frosts, which are likely to occur on nights when the skies are entirely clear during the winter; at such times they make every effort to heat the air in the groves to keep it above the freezing point. This is done by orchard heaters, or "smudge pots" (Fig. 27). Some growers think that the presence of smoke from the heaters helps to prevent loss of heat by radiation.

Fog. The loss of heat by radiation or other chilling of damp air may cause enough condensation to produce fog, which is essentially a cloud at the surface of the earth. When cold air, which is relatively heavy or dense, drains into lowlands from surrounding points, the chilled humid air condenses, causing radiation fog in the lowlands. Fogs resulting from radiation usually disappear during the day. When moving cold masses of air chill warmer air masses below the dew point, the resulting condensation may cause thick and persistent

FIG. 27. Lighting a smudge pot, or orchard heater, in a citrus grove at Arlington, California. Fuel is usually crude oil, though some ranchers use coal briquettes or other substances. (*Photograph courtesy of the U.S. Department of Agriculture.*)

fogs. These are called *advection* fogs to distinguish them from the type that results from radiation (Fig. 28). Such advection fogs are common on the Grand Banks of Newfoundland near the contact between the air above the cold Labrador Current and the water of the warm Gulf Stream. They may also occur when conditions are suitable in the interior of continents. Advection fogs sometimes last for several days and constitute great hazards to shipping, air travel, and automobile traffic. In a fog a temperature below freezing may cause the condensation of moisture in the form of a film of ice on windshields and pavement, handicapping vision and making traffic hazardous. Airplanes sometimes accumulate a dangerous load of ice from the condensation of cold fogs if the planes are not equipped with defrosting apparatus. The frost crystals that accumulate by condensation from cold fogs on trees and other surfaces are called *rime*. Deposits of rime add much to the beauty of winter.

Clouds. When condensation occurs well above the ground, a cloud is produced, consisting of tiny drops of water or frost crystals suspended in the air. *Cumulus* clouds pile up above a flat base to form "cauliflower" clouds, which are common in fair weather and sometimes expand to enormous heights in the thunderheads that accompany local rainstorms (Fig. 29). The flat base represents the condensation level in a rising convection current. *Stratus* clouds are low-lying flat clouds covering the entire sky. They are most common in winter and cause the dark days and skies at that season of the year. *Cirrus* clouds are thin fleecy forms seen at heights of 5 to 9 miles above the earth's surface (Fig. 30). Because the temperature is below freezing at these elevations, cirrus clouds are always composed of frost crystals, even in summer. Halos around the moon or sun are produced by light cirrus clouds. The *nimbus* cloud is any cloud from which rain is falling. Combinations of any of the four types of clouds occur, and descriptive terms are often added, like altostratus ("high"), fractocumulus ("broken"), and nimbostratus ("layer").

Causes for Rainfall. The joining together of the tiny particles of moisture in the clouds produces raindrops, snow, or other forms of precipitation. Since molecules of water displace heavier molecules of oxygen and nitrogen, the air that contains water vapor is lighter than dry air. Since humid air is lighter, it tends to rise, cool adiabatically by expansion, and produce clouds or rain. Once condensation begins, the removal of the water molecules from the air reduces the volume and pressure and allows air from elsewhere to flow in, bringing a fresh supply of warm humid air so that rain once started may continue for a considerable time. Anything that will cool humid air sufficiently to condense

FIG. 28. Advection fog forming over the Golden Gate and moving inland over San Francisco Bay toward the right of the photograph. The Marin peninsula appears in the distance, and part of San Francisco in the foreground. (*Photograph courtesy of the U.S. Weather Bureau, Department of Commerce.*)

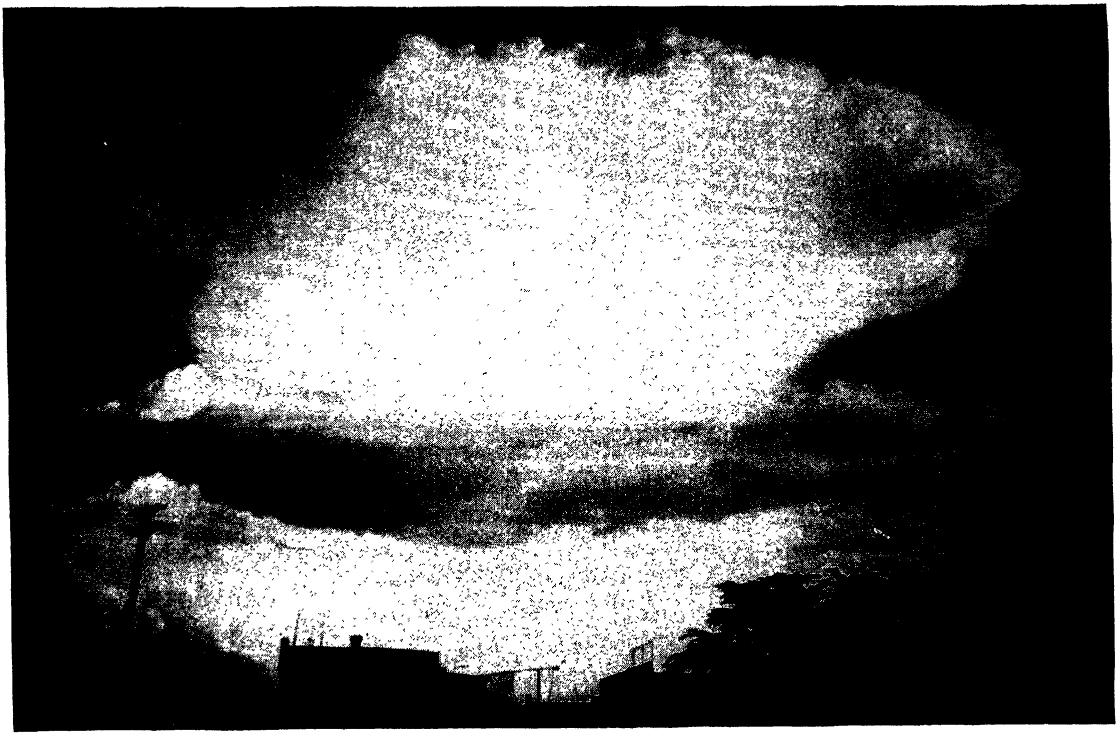

FIG. 29. Cumulonimbus cloud indicating the upper limits of condensation near the top of a rising column of air. This type of cloud often develops into a thunderhead. (*Photograph courtesy of the U.S. Weather Bureau and P. A. Miller of the U.S. Department of Commerce.*)

FIG. 30. Cirrus clouds in small patches of parallel trails. These clouds usually occur at relatively high altitudes in the troposphere. (*Photograph courtesy of F. Ellerman, U.S. Weather Bureau, Department of Commerce.*)

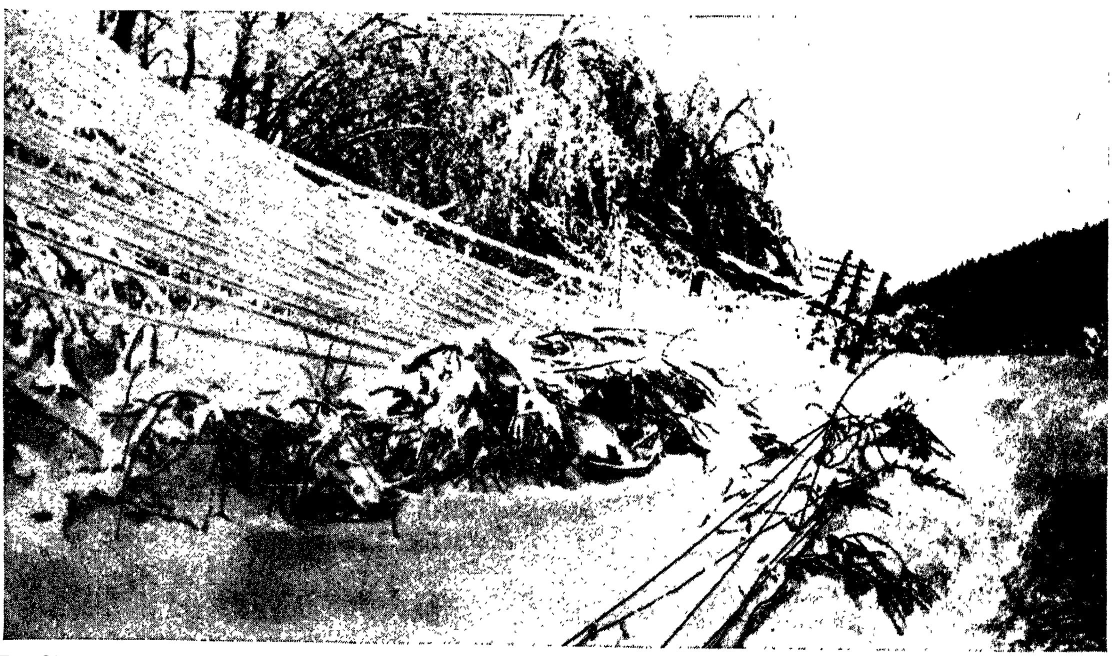

FIG. 31. Severe storm in New York State early in January, 1943. (Note the ice damage to wires, and broken pole caused by weight of ice.) (*Photograph courtesy of the U.S. Weather Bureau, Department of Commerce.*)

the water vapor may produce precipitation. Among the causes for rain are (1) rising of air over mountains; (2) rising of warm, humid, light air over cold heavy air; (3) cooling by expansion (adiabatic cooling) when air rises in convection currents; (4) mixing of cold and warm currents or masses of air; and (5) movement of air from warm into cooler regions.

Ice Storms and Hail. Precipitation usually occurs in the form of rain or snow, but other types are sometimes important. Sometimes the temperature near the ground is colder than at a higher elevation. This abnormal temperature condition is known as a *temperature inversion,* which is favorable for precipitation because the air is then very unstable. When rain freezes while falling, it is called *sleet.* Rain may also freeze on the surface of objects cooled below freezing, even when the air is above that temperature. Under such conditions, rain freezes on the ground and other surfaces and covers everything with a glaze of ice. These ice storms are very destructive to telegraph and telephone wires and even break down trees and make highway traffic dangerous (Fig. 31). The condensation of moisture and its freezing to ice on aircraft and automobile windshields sometimes cause dangerous conditions.

Hail is made of concentric layers of ice and is generally believed to result from the passage of frozen pellets into a layer of warmer air. Moisture condenses on the ice, and then the droplet moves again into a freezing current, which forms a layer of ice around the core. This process continues until the hailstone has grown to a size so large that it falls to the earth. Hail is an accompaniment of thunderstorms in warm seasons of the year when very strong updrafts or convection currents may carry the raindrops high up into air of freezing temperatures.

PROBLEMS

1. Explain the statement that "at a constant temperature the volume of air varies inversely with the pressure."
2. Why does one breathe more rapidly at high altitudes?
3. Why is a man not crushed by the great weight of air (15 pounds per square inch) pressing on his body at sea level?
4. Why is relative humidity usually higher at night than in the day?
5. Why does not dew form every night?
6. What is the significance of a series of isotherms crowded closely together?
7. What would be the effect on horizontal movement of air if isobars are close together?
8. Explain the location of high- and low-pressure belts on the isobaric map (Fig. 26).
9. Calculate relative humidity (*a*) when the air temperature is 80° and the wet bulb is 70° and (*b*) when the dry bulb reads 50° and the wet bulb 40°.
10. In the words isobar and isotherm, what is the meaning of the prefix *iso-*? of the suffixes *-bar* and *-therm*?
11. "Relative humidity at noon yesterday was 62.5 per cent." Explain the statement. Would the air seem dry, damp, or medium?
12. Indicate which are forms of precipitation: rainfall, snowfall, hail, dew, sleet, frost, cloud, fog, mist.
13. Why does a water body usually warm more slowly than a land mass?
14. How does the weight and density of the air change with increase of altitude?
15. Which condition is usually preferred for human activity:
    Low temperature, low relative humidity.
    Low temperature, high relative humidity.
    High temperature, low relative humidity.
    High temperature, high relative humidity.
16. Why does air tend to flow from regions of high atmospheric pressure to those of lower atmospheric pressure?
17. If the mercurial barometer reads 30.2 inches this morning, is the air pressure relatively high or low?
18. If the mercurial barometer reads 30.2 inches this morning, but all weather stations around you report readings higher than 30.2, are you in the center of a "low" or of a "high"?
19. What is usually referred to when the amount of moisture in the air is compared with the amount it could hold at the same temperature?

20. How are the effects of altitude upon pressure removed from isobaric maps?
21. What is the usual weight of the atmosphere at sea level?
22. Which type of air can include more water vapor, a "low" or a "high"?
23. Why is mercury commonly used in barometers? What would be the disadvantages of water?

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CHAPTER 4: *Winds, Storms, and Weather*

Winds

A horizontal movement of air is termed wind. Winds blow at the surface of the earth from regions of high atmospheric pressure toward those of lower air pressure. Winds are named from the direction from which they blow. Differences in air pressures on the earth appear to result chiefly from differences in temperatures following variations in the receipt and distribution of solar energy described in Chap. 3 under Insolation.

Calms are areas with no noticeable winds, although the air may be rising or descending. The velocity with which winds blow toward a low pressure area depends on the difference in pressure compared with the distance involved, and is called the *pressure gradient.*

A difference of 1 inch in the barometer reading within a distance of a few miles would be a steep gradient and would cause winds of high velocity; whereas, if it were spread over 1,000 miles, an equal difference in pressure would be a gentle gradient and would cause only a light breeze.

As the air ascends to upper levels of the troposphere, it is released from contact with the earth's surface. This freedom from land-air friction tends to increase wind velocity at high altitudes. Gusts and lulls in the wind result from convection and irregularities on the earth's surface which cause eddies. Gustiness and turbulence of the wind mix the air and carry water vapor and dust high into the atmosphere. Table 2 describes winds according to their velocity.

TABLE 2. BEAUFORT SCALE OF WIND FORCE

Beaufort number	*Name*	*Characteristics*	*Velocity, miles per hour*
0	Calm	Smoke rises vertically	Less than 1
1	Light air	Smoke drifts	1 to 3
2	Slight breeze	Leaves rustle	4 to 7
3	Gentle breeze	Leaves and twigs move constantly	8 to 12
4	Moderate breeze	Raises dust and small branches move	13 to 18
5	Fresh breeze	Small trees sway	19 to 24
6	Strong breeze	Large branches move	25 to 31
7	Moderate gale	Whole trees in motion	32 to 38
8	Fresh gale	Tree twigs are broken	39 to 46
9	Strong gale	Some damage occurs	47 to 54
10	Whole gale	Trees uprooted and limbs broken	55 to 63
11	Storm	Widespread damage	64 to 75
12	Hurricane	Great damage	Above 75

Local Winds. It has been noted that, when land is intensely heated, radiation from the warmed earth in turn heats the air, which then expands and causes some of the air to move aloft. Then cooler and heavier air from surrounding regions flows in to push up the warm air, which when aloft spreads horizontally to complete the convection current. In reality, the whole operation is a continuous movement.

A common local convection current along sea and lake coasts is the *land and sea breeze* (Fig. 32). On a sunny day the temperature of the land may be warmer than that of the

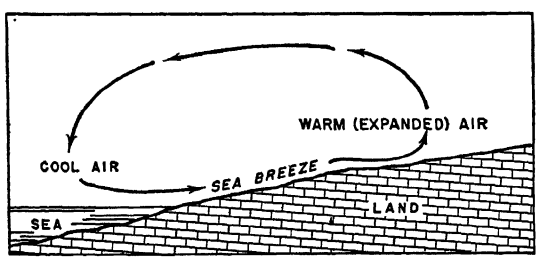

FIG. 32. Daytime temperature conditions causing the sea breeze. At night, both temperatures and wind directions are reversed, causing the land breeze.

adjacent ocean. In consequence air expands over the warmed land until at some height the pressure exceeds that above the water, causing the air aloft to move seaward. This increases the pressure over the water to more than that at the land surface, forcing a drift of air to the land from the sea, and thus completing the convectional current. This results in a sea breeze during the day, usually beginning before noon and ending about sunset. On clear nights the earth may radiate heat more rapidly than the water, and in consequence during the night a land breeze blows seaward, ending about sunrise. Fishermen using sailboats may time their departure to leave with the land breeze before dawn and return with the sea breeze before sunset. The sea breeze helps make ocean beaches attractively cool to visitors in summer. It rarely extends inland more than 50 to 75 miles.

Other types of local winds are those between the mountains and valleys, blowing in opposite directions during day and night. After sunrise the earth is warmed by insolation and radiation. In turn, radiation from the earth heats the air, which rises, and cold air flows in, forcing the warm light air to expand and move up the slopes of the mountains, forming what is often called the *valley breeze,* a daytime phenomenon. Frequently the moisture in the rising cooling air condenses to form clouds over the mountain summits. At night the air at higher elevations loses its heat by radiation and becomes denser as the result of cooling. This colder and heavier air slides down the mountain slopes toward the valleys and plains, forming the *mountain breezes.* From the lowlands the warm air is forced to rise by the cold and flows at higher elevation over the mountains, thereby completing a convectional current.

The temperature of air that descends thousands of feet down mountain slopes may be increased by many degrees because of warming by compression as a result of the increased weight or pressure of the air. This fact accounts for the *foehn* or *chinook* winds (Fig. 33). Humid air rising over mountain ranges loses most of its moisture by condensation, which follows cooling by expansion. When it sinks to leeward of the mountains, the air is warmed correspondingly as it descends the slopes. Unsaturated rising air is cooled 5½°F. per 1,000 feet and sinking air is warmed at the same rate, but rising saturated air cools 3°F. per 1,000 feet owing to addition of heat of condensation. The air descending the leeward side of mountain ranges may therefore have a higher temperature at the foot of the mountain than does the air that is beginning its ascent on the windward side (Fig. 34). This dry air can melt or evaporate snow rapidly on leeward sides of mountain ranges, thereby permitting the grazing of livestock most of the winter in areas that would otherwise be too cold.

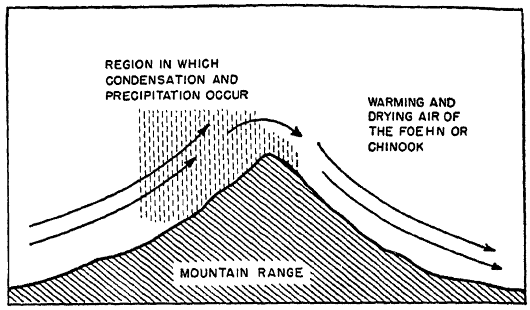

Fig. 33. Air movements illustrating the development of foehn, or chinook, winds.

Circulation of Winds on the Globe. The causes for the planetary circulation of the winds are complicated, and the full explanation would require a mathematical treatment beyond the scope of this book. (Those interested should consult W. J. Humphreys, "Physics of the Air.") The following brief explanation is necessarily incomplete, but frequent reference to Fig. 36 will be of much help in understanding the pattern of winds and calms.

Circulation on a Nonrotating Globe. Let us consider first the circulation of air that would exist on a nonrotating globe of uniform surface. As shown in Fig. 35, the air would be heated most near the equator, where insola-

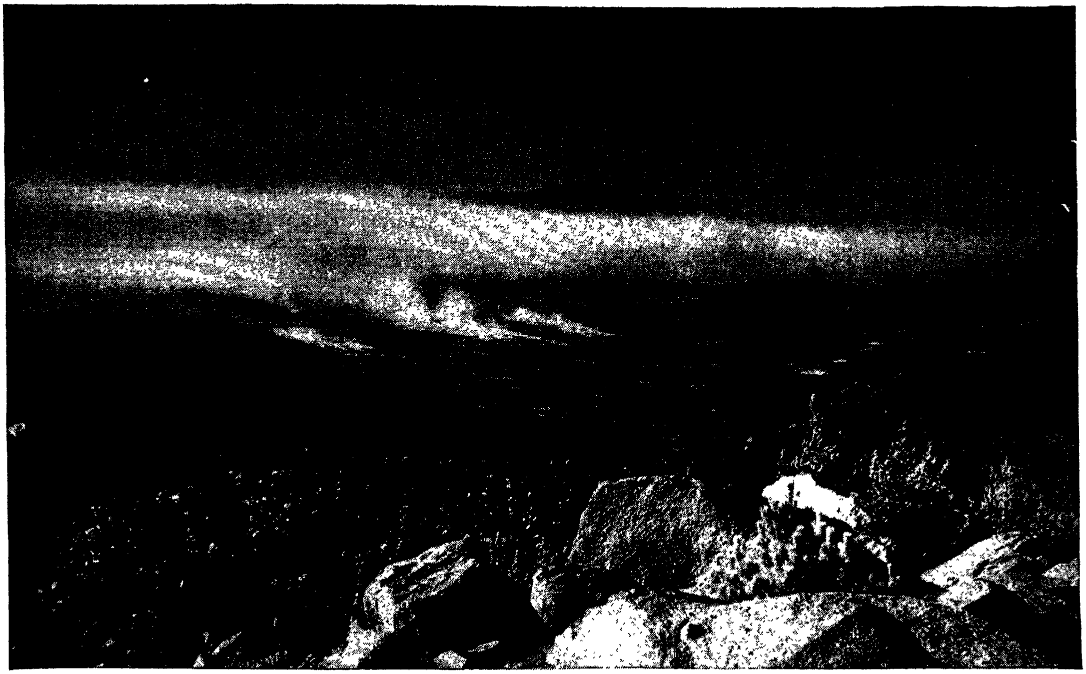

FIG. 34. View toward the west from the San Bernardino Mountains, across Cajon Pass. A high foehn wind is carrying large amounts of dust down the pass toward the Los Angeles lowland, and the air is warming as it descends. Mountaintop coniferous forest covers the summits at this altitude. *(Infrared photograph by Robert Pease.)*

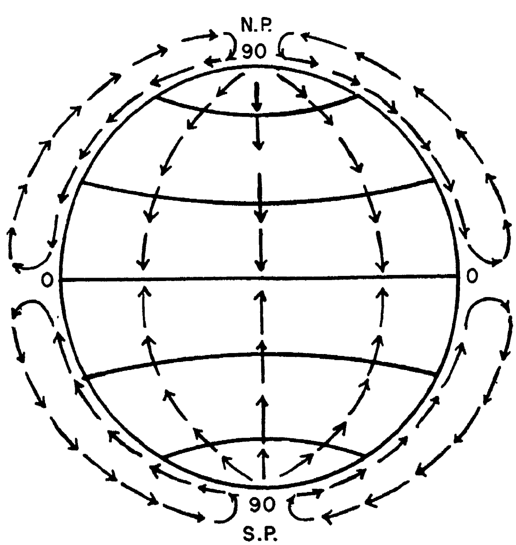

FIG. 35. The circulation of air on a nonrotating globe of uniform surface.

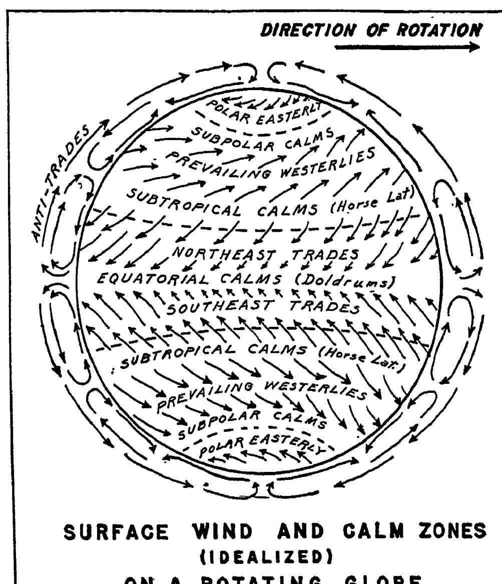

FIG. 36. Surface wind and calm zones (idealized) on a rotating globe.

tion is greatest. Above the ground some of the expanding air would move sideways, thereby increasing the pressure on either side of the equatorial region and helping to cause an influx of cold air from higher latitudes, which would force up the warm air at the equator. The result would be a huge convection current of air moving clear from the poles to the equator, rising there, and flowing at a high elevation toward the poles, where it would settle to complete the circulation.

Effect of Earth's Rotation. The ideal circulation of winds on the earth differs from the foregoing, because the rotation of the earth deflects the winds and thereby changes their directions. William Ferrel, nearly a century ago, showed that anything that moves freely over the surface of a rotating globe will be deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. In the Northern Hemisphere air coming from the north would be deflected toward the west, thereby becoming an easterly wind, and air moving from the south would be deflected toward the east, thereby becoming a westerly wind. In the Southern Hemisphere the south wind would be deflected by the earth's rotation to the west, becoming an easterly wind, and a north wind would be bent toward the east to become a westerly wind.

Names and Location of Wind Belts. Experience shows that, in the equatorial zone and extending a few degrees on either side, there is a belt of rising and expanding air which has rather low pressure at the earth's surface. This zone is one of light variable airs and calms and is called the *doldrums* or *belt of equatorial calms* (Fig. 36). Here the heated air is forced to rise by the inflow of colder air from either side of the equator. The rising air cools by expansion, causing almost daily thunderstorms, from which the rainfall is often torrential.

From around 30° to 35°, both north and south latitude, the pressure is high, and masses of relatively cool air blow toward the low pressure of the doldrums. These winds are called *trade winds* and are deflected by the rotation of the earth, although not so rapidly as in high latitudes, so that they blow from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere. The trades are relatively steady winds and in the days of sailing ships were very useful because of their reliability. Fair weather predominates in the trades except where the winds blow from the ocean onto a mountainous coast; this situation promotes local heavy rainfall.

Intertropical Front. The trade winds are not constant in physical characteristics but may vary in temperature, humidity, and density. Then, instead of the two trade winds blending together to form doldrums, the trade wind with the colder and denser mass underrides the warmer, lighter, and usually more humid mass of trade-wind air and forces it to rise, resulting in cooling and condensation. The doldrums are absent under these conditions, as for example in the central and eastern tropical Pacific zone. The junction of the trade winds, whether the doldrums are formed or not, is called the *intertropical front.*

Above the trade winds at high altitudes are *antitrades,* which contain the air that rose in the doldrums and during the process lost most of its moisture in consequence of the process of cooling on expansion. The air, after rising, moved away from the doldrums—from the south in the Northern Hemisphere and from the north in the Southern Hemisphere. The earth's rotation causes these winds, called antitrades because they lie above the trades and blow in opposite directions, to be deflected so that, when they descend to the earth at about one-third of the distance to the poles, they blow from the southwest north of the equator and from the northwest south of the equator. The zone of air descending from the antitrades has high pressure, in part because the air piles up, under the conditions there, and also because it is dry and cold. Here surface winds are light and variable and the weather is usually fair. This zone is called the *belt of subtropical calms* or the *horse latitudes.* There

are two such zones, one in each hemisphere, at about 35° from the equator. From the horse latitudes some of the descending air returns toward the equator in the trade winds, but some continues to flow poleward, is further deflected by the rotation of the earth, and becomes the prevailing westerly winds.

The *prevailing westerlies* are situated between about 35° to 40° and 60° to 65° north and south from the equator. Their boundaries fluctuate, particularly along the poleward margins. Near the horse latitudes these winds come from the southwest in the Northern Hemisphere and from the northwest in the Southern Hemisphere; but the deflective effect of the earth's rotation increases poleward, causing the winds to blow predominantly from the west toward the outer limits in both hemispheres. The prevalence of cyclonic storms causing frequent changes in temperature and rainfall and other weather phenomena is an outstanding characteristic of the two zones of prevailing westerly winds.

Toward the poles, especially over ice-covered lands like Greenland and Antarctica, air that flows in at high elevations is cooled and sinks toward the earth. This cold air forms an area of high pressure (*polar high*) from which cold air moves out; and, in accordance with Ferrel's law, these winds are deflected to the west in both hemispheres to form the *polar easterlies*. The amount of deflection due to the earth's rotation in high latitudes is so great that these winds, starting south from the north pole and north from the south pole toward the equator, are soon deflected 90 degrees from their original courses until they blow directly from the east. Between the polar easterlies and the prevailing westerlies lie the so-called *subpolar lows*. Probably this zone of low pressure in part results from a withdrawal of air aloft that results from polar cooling and from the surface air movement away from the polar highs, but the explanation is too complicated for further discussion here. Of special interest is the fact that the two subpolar lows are among the stormiest belts in the world. Many of the storms that cross North America develop in the Aleutian low. In the North Atlantic many storms reaching Europe come from the Icelandic low, which occupies a similar position in that ocean.

The location of the various wind belts is affected by the seasons and the resulting changes in heating of the earth. The whole system of winds shifts northward during summer months and southward during the winter months of the Northern Hemisphere. The pressure (isobaric) maps of the world (Figs. 25 and 26) show a belt of low pressure near the equator and a zone of high pressure in the subtropics, centering about 25° to 35° from the equator, as noted previously. The trade winds blow from the high- to the low-pressure belts. Then in the polar regions high pressure prevails, and the winds blow equatorward toward the subpolar low-pressure belt that lies about 60° to 65° from the equator. The westerlies blow between the high pressure of the subtropics and the lower pressure in the subpolar region.

Monsoon Winds. In origin, monsoons resemble land and sea breezes on a giant scale, because they may affect most of a continent and blow for weeks or months at a time from the sea in summer and the land in winter, completely reversing their directions with the seasons. The pattern of the ideal circulation of the winds shown in Fig. 36 is interrupted in some parts of the earth because of the different influences of large land bodies and oceans. Oceans heat more slowly than continents but likewise retain heat longer. As a result, oceans have smaller seasonal ranges of temperature. A large continent like Asia becomes thoroughly chilled in winter and is surmounted by heavy cold air, flowing as a surface wind outward to the sea. This winter monsoon is a cold dry wind. The winter monsoon brings rain only to parts of southeastern Asia after blowing across bodies of water before striking the land.

In summer part of Asia, especially in the Thar Desert of northwest India, becomes so hot that the air, heated by radiation from the land, expands and part flows out to the cooler

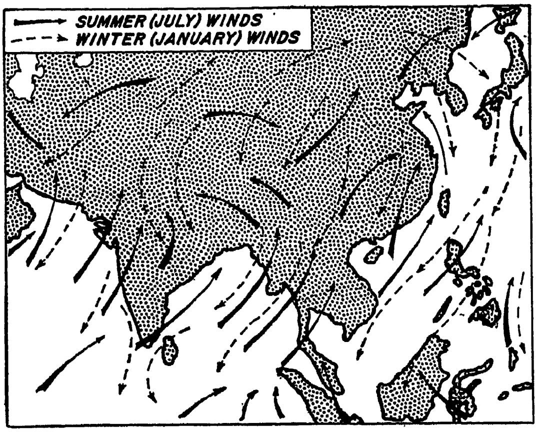

FIG. 37. Monsoon winds of southeastern Asia. Note the general landward movement of air in summer and seaward movement in winter.

oceans over which extensive high-pressure areas develop. From the oceanic high-pressure areas surface winds blow in from the sea, bringing summer rains to the continent, on which a large low-pressure area exists. In winter conditions are exactly reversed (Fig. 37).

In India the summer monsoon originates south of the equator in the southeast trades, which are deflected toward the northeast as the wind enters the Northern Hemisphere, thus flowing directly counter to the normal direction of the northeast trades. Both summer and winter monsoons may last for several months with little respite. The summer monsoon brings summer rains to southeast Asia and is of tremendous importance to the people who live there. Some of the world's most densely populated areas are in the monsoon region. The winter monsoon is usually dry, but rain results when it blows across a large body of water like the Bay of Bengal and then rises over a mountainous land such as Ceylon.

Between the monsoon seasons the normal trade winds may blow. Southeastern Asia is the best example of a monsoon region, but the southern United States and Río de la Plata region of South America are among the parts of the world having summer rains which, though not true monsoons (because the winds are not completely reversed in the winter), do come from nearby oceans and are of great importance to growing crops. In former years, sailing ships left Europe to arrive in the Indian Ocean in time to hasten to India with the summer monsoon behind them; the winter monsoon speeded their return voyage.

Winds and Man. The winds of the world exert pronounced effects upon man and his activities. Winds of steady force like the trade winds, monsoons, and prevailing westerlies were an important influence in the selection of the routes followed by sailing vessels. Islands and windward coasts have a marine or oceanic climate with small range of temperature. Leeward coasts and the interiors of continents, except in the tropics, have larger seasonal extremes of temperature. Trade winds blowing toward the equator have increased ability to evaporate and retain moisture as their temperature rises, and they may consequently cause desert conditions unfavorable for human life except on high windward coasts where they bring much rainfall. Rainfall contrasts between southeastern and southwestern Africa (Fig. 47) illustrate the point. Variable weather is a feature of the prevailing westerlies and helps the development of civilization in mid-latitude regions. Small frequent changes of temperature, humidity, and sunshine or cloudiness have beneficial effects on man, but great extremes are harmful. The zone of prevailing westerlies is believed by many to have just the changeable weather conditions that favor man.

Weather

The condition of the atmosphere at any one time constitutes the weather. Temperature, humidity, air pressure, winds, and other phenomena characterize it. Climate represents a composite of weather conditions over a long period of time. Weather and climate are affected by such things as directness of the sun's rays and length of day, the distribution of

land and water bodies, altitude and position with respect to mountains, air pressure, storms and their frequency, movements of air masses, and winds and ocean currents. Climate not only is the average of all weather conditions but also takes into account the extremes or variations that may occur in departures from the average conditions.

Storms. Storms are among the most familiar phenomena of nature. They provide the rain that falls on the earth and some of the warmth that is essential to life. The shifting of variable winds and many other meteorological changes are associated with them. Storms result from differences in pressure which cause the movement of masses of air and produce the variable weather so characteristic of parts of the earth's surface. Some storms are local and are mere convectional thunderstorms of small extent, whereas others are so large that they may cover half the territory of the United States. A storm center has lower pressure than the surrounding regions, and air tends to flow toward this center from regions of higher pressure near it. As previously described, the moving air is deflected by the rotation of the earth to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. Air moving in toward the storm center in the Northern Hemisphere thus tends to spiral in a counterclockwise direction, and in the Southern Hemisphere it spirals in the reverse direction, or clockwise (Fig. 38).

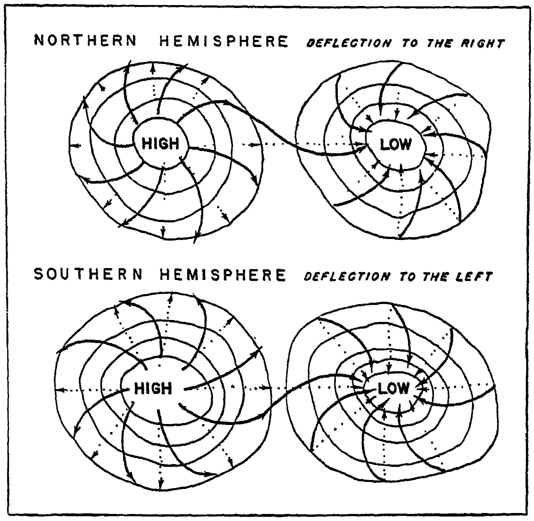

FIG. 38. Idealized movement of air around "highs" and "lows" at ground level in the Northern and Southern Hemispheres. (Note the counterclockwise motion of air toward the center of a "low" of the Northern Hemisphere.) Dotted lines indicate the direction in which the air started to move originally; solid lines indicate the deflected movement.

Cyclonic Storms. The greatest type of storm results from the general circular way in which winds blow around low-pressure areas toward the centers, as just described. Such storms are called *cyclones* and should not be confused with tornadoes, the destructive storms described later. Cyclones, often called "lows," appear on weather maps as oval or elongated areas with air pressure lower than that of surrounding regions. In the lows the air is generally rising toward the center. On the weather maps of the United States the opposite areas of high pressure are labeled "highs" and are technically called *anticyclones*. Air descends in highs, and the wind spirals outward, clockwise in the Northern and counterclockwise in the Southern Hemisphere, as a result of the effect of the earth's rotation on the moving streams of air.

Cyclones may occur in either the tropics or the extratropics of the middle and high latitudes, but they are most common in midlatitudes. A cyclone has the shape of a huge flat saucer. Cyclonic disturbances vary tremendously in size. In general, however, they are very large and may have a width of 500 to 1,000 miles or more; but, since they are confined to the troposphere, they are only 5 to 8 miles in depth. In the winter they are often much elongated, generally in a north-south direction, and one axis may be twice as long as the other.

In mid-latitudes the lows are gigantic eddies in the stream of the prevailing westerly winds, in which they have a tendency to move eastward. The storms may move thousands of miles before wearing themselves out and disintegrating. Their rate of movement varies greatly, but in general a cyclonic center will

move in an easterly direction from 400 to 600 miles per day, with occasional storms that are slower or faster than these figures. Such storms usually require from 3 to 5 days to cross the width of the United States. Certain tracks are commonly followed by cyclonic storms. For example, in winter most lows enter the United States near Puget Sound, loop across the country in a southeasterly direction to the Mississippi Valley and thence northeastward, and continue on to the Atlantic. Other storms enter the United States from the southwest and move in a northeasterly direction. In summer the paths of the lows are generally farther north than in winter. The diagram (Fig. 39) shows the customary paths for storms of the Northern Hemisphere. The wind velocity in the cyclone is rarely high enough to do serious damage. Occasionally winds of 50 to 75 miles per hour will be associated with a low on exposed coasts or open plains country, but generally winds connected with them have only a fraction of this velocity. As a low passes over an observer, a definite shift in the wind direction is usually noted. As a rule, winds in front of a storm are warm and blow from the southeast, while back of the low a cold wind blows from the west, northwest, or north.

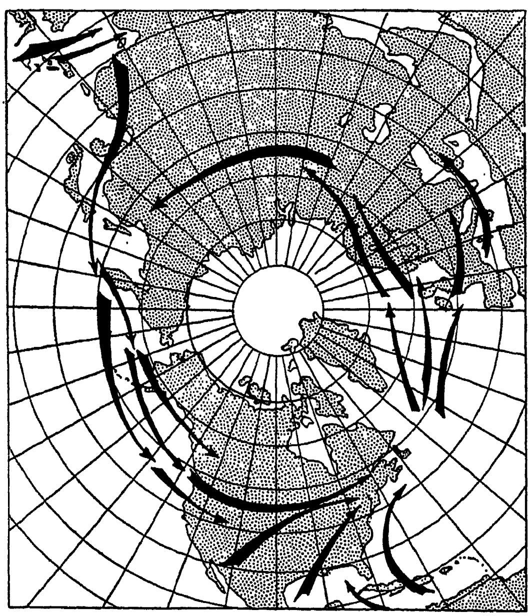

Fig. 39. Principal storm paths of the Northern Hemisphere. (Note that the storms tend to develop over sea areas.)

Warm and Cold Fronts. Studies indicate that a low develops essentially near the zone of contact between two moving air masses—one consisting of warm tropical air and the other of cold polar air. Since the lows are storm areas and develop in the zone of the prevailing westerly winds, the outstanding characteristic of climate in the mid-latitude zones of these winds is variability. Alternating storminess and fine weather dominate these regions. Here is the line of contact between cold, dry, heavy, equatorward-moving air masses from the polar regions, and warm, lighter, humid, poleward-moving air masses from the subtropics. At intervals of many hundreds or even thousands of miles, moving tongues of cold and warm air come in contact, and the cold air mass underrides the warm air, forcing the latter to rise; or at times the cold air mass may be more or less stationary, and the warm air mass will override the cold air mass. This results in cooling, condensation, and finally development of the whirling storm areas called cyclones.

If a cold air mass is relatively stable and a warm air mass advances and overrides the cold mass, the advancing line or zone of discontinuity is called a *warm front.* This is usually accompanied by high light clouds—cirrus and cirrostratus—and by a falling barometer as the central part of the "low" approaches the location of the observer. Later, lower and more dense clouds with some rain or snow may follow before the storm ends.

On the other hand, if a mass of cold air advances at ground level and acts as a wedge to lift warmer moist air to higher altitudes, the contact zone is called a *cold front;* the resultant cooling of the warm air because of increase of altitude will then bring storm conditions along the advancing cold front. Generally the storms generated by a cold front are severe, with linear arrangement—the squall line—and heavy dark clouds of the thunder-

head type. Atmospheric pressure rises suddenly with the arrival of the cold front, and clearing and relatively cold weather may be expected after the storm passes by.

It is apparent that cyclones and anticyclones must be in contact with each other and that, when the zone of contact between two large air masses differing in temperature and pressure is constricted between them, the atmosphere may become highly unstable. This occurs particularly when a mass of cold air from the anticyclone moves out above ground level toward the warm air mass of a nearby low. This circumstance brings instability in which cold relatively heavy air lies at a higher altitude than warm light air, and the former tends to sink at once toward the ground level, creating much disturbance of the atmosphere; some of the worst storms may develop under such conditions.

The condensation of moisture in the cyclone releases latent heat which expands the air and reduces the pressure letting more in from all directions toward the resulting low pressure area. This process of engulfment of a mass of warm air is termed *occlusion;* the warm air of the low is lifted above ground level, and an *occluded front* is formed. Once begun, the air tends to spiral in toward the storm center, which moves with the prevailing winds like a giant whirl. Continued condensation of the water vapor brought into storm centers, mostly by the warm fronts that have originated over the oceans, supplies the energy for the perpetuation of the cyclones.

Origins and Characteristics of Air Masses. The primary classification of the origins of air masses is either polar, represented on weather maps by the capital letter *P,* or tropical, *T.* A secondary division indicates marine, *m,* or continental, *c,* origin. Further characterization of each mass involves a description of its temperatures, either warm, *W,* or cold, *K.* Air masses in which the conditions favor stability at high altitudes also are labeled *s* for stability; those in which instability is present are marked *u* for unstable. Thus an air mass described by the letters *mPKu* indicates that it is of ocean origin coming from the polar or subpolar regions, having temperatures cold for its latitude and season, and in a condition that would lead to instability or storminess. Air masses of this type are common over the North Atlantic Ocean in winter and over northern Siberia in summer.

In North America, *cP* air masses originate in Canada and tend to move southward east of the Rocky Mountains, bringing low temperatures to the eastern states along a lengthy advancing edge of cold air which is termed the *polar front.* Air reaching the interior of the United States in winter may also come from the North Pacific (*mP*), bringing comparatively mild winter weather to the Pacific Northwest. Marine tropical air (*mT*) enters the continent primarily from the Gulf of Mexico, but occasionally it originates near the Gulf of California and moves inland. This air mass usually is moist and warm, and it requires little contact with *cP* or *mP* air to cool it sufficiently to produce clouds and rain. Marine tropical air from the Gulf of Mexico is a principal source of summer rainstorms in the eastern part of the United States. The modified weather map (Fig. 40) will illustrate these points.

Ahead (east) of a low in the northern latitude is the advancing warm front of a subtropical air mass (Fig. 41). Following the low, west of the center in northern climes, is the cold front or frigid air mass from the polar region, as described above. The cold air mass has high pressure because it is cold and dry and is essentially what has been called the anticyclone. As a low approaches, high cirrus clouds appear, to be replaced by stratus and finally by the rainy nimbostratus clouds. The warm air is lighter than any cold stagnant air that may be in a region; and, if this warm moisture-filled tropical air mass rises or is forced upward, rainfall may result along this warm front. Thus rain is expected in front (that is, east) of the cyclonic center.

After the center has passed by, the sky clears upon the arrival of colder and drier air. Southwest of the cyclonic center is the contact be-

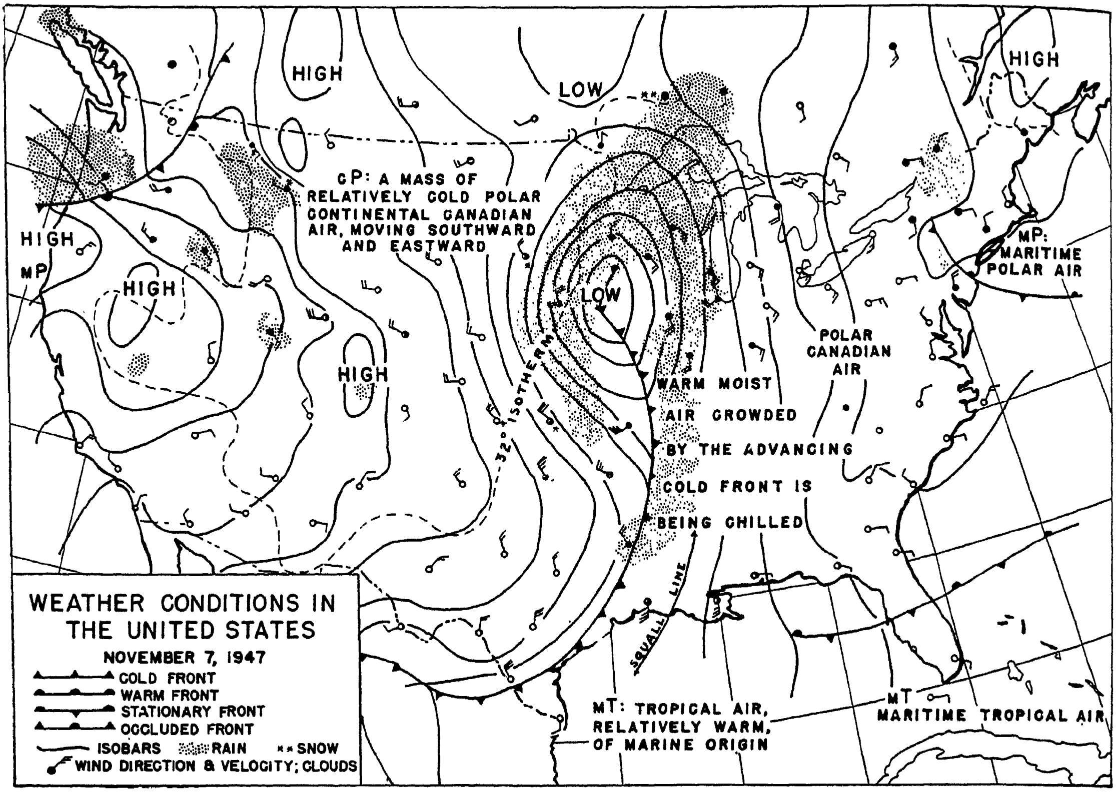

FIG. 40. Weather conditions in the United States, November 7, 1947.

tween the warm and cold air masses. Here the mild humid southerly winds of the warm front are suddenly replaced by cold air coming with the west or north winds. In the zone of contact between the two air masses a sudden fall in temperature may result in heavy precipitation. Here are produced squalls, severe local "line" thunderstorms, and sometimes destructive tornadoes. Hail often accompanies thunderstorms in this zone called the

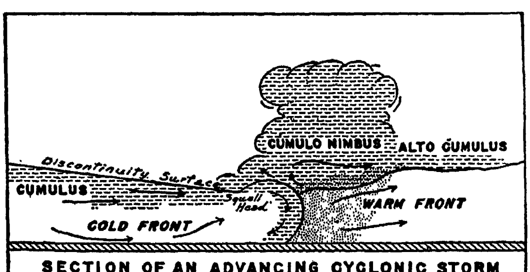

FIG. 41. Cross section of an advancing cold front with associated weather conditions.

wind-shift line. Tornadoes are usually in advance of the squall line because the cold air comes in aloft well ahead of the surface cold air and occasionally helps to cause such turbulence and local instability of the air that a tornado develops.

In some years cyclones are more numerous or more severe than in other years. Evidence has been collected to show that lows tend to move in cycles. For several years the storms increase in frequency and strength to a maximum and then decrease to a minimum. Some authorities recognize an 11-year cycle and another of about 35 years' duration; and the late Ellsworth Huntington, among others, believed in a swing measured in centuries rather than years. There seems a fairly close correspondence between abundance of cyclones and frequency of sunspots, which suggests that a possible ultimate cause for variations in storminess lies in pulsating radiation from the sun.

Scientists are not agreed upon the absolute and final cause for cyclones, and it may be that more than one factor is involved in the formation of these giant whirls in our atmosphere.

Weather Forecasts and Cyclonic Paths. The U.S. Weather Bureau forecasts weather a few days in advance. When lows appear off the Pacific coast, they usually follow easily recognized paths across the country. If the storm follows a usual course and moves eastward about 500 miles each day, warm and rainy weather will advance across the continent at the same rate. After the passage of the low the normal weather in the high that follows is likely to be clear and colder. Forecasts made for tomorrow's weather by the Weather Bureau are correct about 90 per cent of the time. Forecasts fail when lows and highs move faster or slower than the normal rate, or change directions. Storms occasionally disappear or suddenly gain in strength and destructiveness.

The weather of the country is profoundly affected by the paths that are taken by the cyclones. When lows cross the southern United States in winter, usually a "norther" or cold wave moves in from the arctic and chills the interior of the country. On the other hand if the low crosses the northern United States, warm winds from the Gulf of Mexico bring mild and usually rainy weather over most of the interior and eastern sections of the country. Experience enables the Weather Bureau employees to forecast with much accuracy. Sometimes a mass of air stagnates and fails to advance as usual. Under this condition, if a warm air mass of high humidity, say from the Gulf of Mexico, continues to flow inland and precipitation results upon contact with cold polar air, the resulting rain or snow is localized over a limited area. These prolonged heavy rains may produce destructive floods or snowfall to a depth of several feet, blocking highways and railroads and disrupting traffic and human activities in general.

Use of Weather Forecasts. Forecasts of weather made 24 to 48 hours in advance are used by many people. Farmers need forecasts of rain during haying, harvesting, and fruit picking. Growers of citrus fruits, peaches, and other crops need frost forecasts to prepare for destructive temperatures that may damage their product. Stockmen need warnings of cold waves, snow, sleet, or blizzards that endanger their livestock. Highway workers and city street cleaners need forecasts of snow to prepare for its removal. Resort operators and picnickers like to know whether given days will be rainy or dry and hot. Shippers sending perishable foods by train should know the probable temperature so that they may protect fruit and vegetables in transit. Ships need hurricane warnings so that they may seek protected harbors, and inhabitants of exposed coasts need to know when to flee inland for safety before the arrival of fierce gales. Fishermen watch the forecasts and time their activities accordingly. River flood warnings form a part of the forecast work of the Weather Bureau. Snow surveys are made in mountainous regions of the western United States to determine the amount of water available for irrigation and power uses during the following summer season. Fire-hazard weather forecasts are made when forests have dried out during hot, dry, windy days. Air lines are given advice about the flying weather to be encountered along the courses to be flown by their planes.

Cooperative Observers and Weather Instruments. The U.S. Weather Bureau is aided in the collection of climatic data by thousands of cooperative observers who record maximum and minimum temperatures, amount of rainfall, snowfall, condition of cloudiness, wind directions, dates of killing frosts, and other phenomena. The data collected by these volunteers supplement those secured through regular weather stations maintained by employees of the U.S. Weather Bureau.

A cooperative weather observer is furnished a rain gauge and maximum and minimum

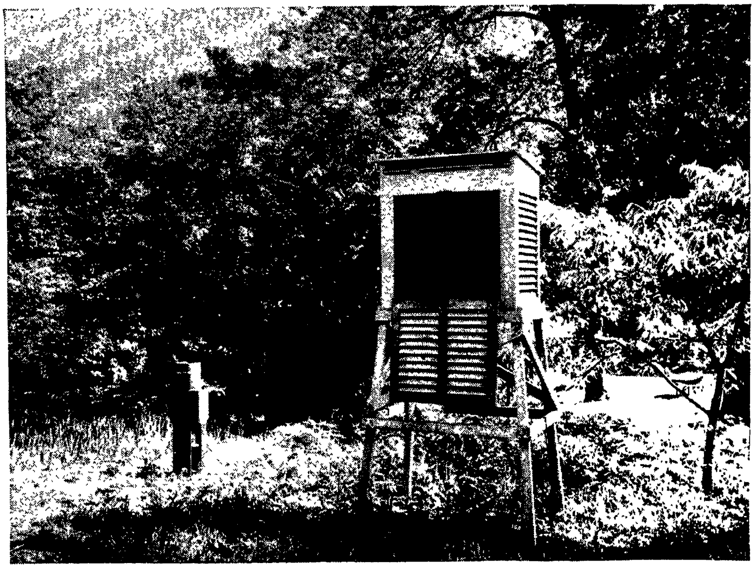

FIG. 42. Standard instrument shelter for cooperative weather observers. (Note that the observations are made in an open space not too closely surrounded by trees and shrubbery.) The rain gauge stands at left of the shelter. The door of the instrument shelter is open. Shelter is well ventilated by openings and by an air space under the roof. (*Photograph courtesy of the U.S. Weather Bureau, Department of Commerce.*)

thermometers. The rain gauge is a cylinder with a funnel-shaped cover which collects rain from ten times the area of the cylinder (Fig. 42). The depth of water in the gauge is thereby magnified ten times and $\frac{1}{10}$ inch of water collected represents $\frac{1}{100}$ inch of precipitation, the smallest amount that is recorded. Snow is melted to convert it into inches of rainfall for the records. Usually about 10 inches of new-fallen snow is equivalent to 1 inch of rain, but snow may be lighter or denser than this.

An ordinary thermometer consists of a capillary tube attached to a bulb containing a fluid that expands and contracts in the tube in accordance with temperature increase or decrease, thus permitting the reading of temperatures. A maximum thermometer has a constriction in the tube just above the bulb which causes the column of mercury to break when the temperature falls, leaving fluid to record the highest temperature reached. Whirling the maximum thermometer forces the excess of mercury to return to the bulb and resets the instrument for the next reading. A minimum thermometer has a double-headed pin in the tube which is pulled down by the surface tension of the fluid, alcohol.

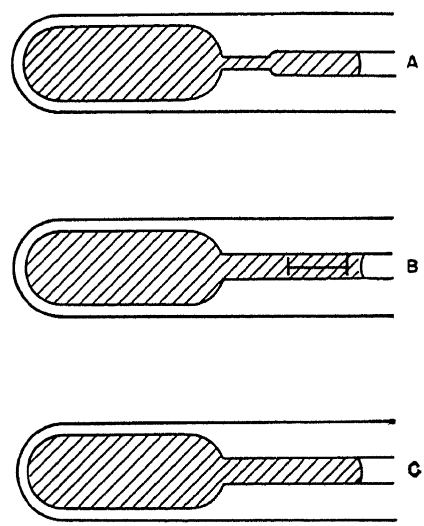

FIG. 43. Construction of thermometers. *A*. Lower part of maximum thermometer. (Note the constriction that holds the mercury at the maximum temperature registered until the instrument is reset by the observer.) *B*. Minimum thermometer. (Note the small float that indicates the lowest temperature and remains there until the observer resets the instrument.) *C*. Ordinary mercurial, or liquid, thermometer.

Alcohol is used because it has a lower freezing point than mercury (Fig. 43-B). When the alcohol is heated, it expands above the pin without moving it. The reading for the lowest temperature since the last observation is made on the right-hand head of the pin. The instrument is set by tipping, and the pin slides down the tube to the end of the column of alcohol. After the instruments are set, both the maximum and minimum thermometers are left at rest horizontally until the next observation.

Thunderstorms. Thunderstorms, a common local phenomenon in hot weather, often accompany areas of moderately low pressure. The storm may originate from convectional overturning of heated humid air, or it may be associated with extensive cyclonic disturbances. The heat, or convection, thunderstorms may occur almost daily at certain seasons in the calm humid equatorial regions. Scattered thunderstorms frequently come during the afternoon or evening of hot days in humid parts of mid-latitudes, generally developing on sultry days. The air, heated by radiation from the earth, expands, and the vapor in the air that cools because of expansion condenses to form a flat-bottomed cloud that rapidly grows into a towering thunderhead (Fig. 44). Surface air moves in toward the low-pressure area, which develops and forces the warm air upward, and the thunderstorm begins to operate. Having begun, the thunderstorm moves with the prevailing winds until its supply of energy is exhausted and it disintegrates.

The condensation of moisture and the formation and separation of raindrops develop static electricity. The larger drops usually carry positive electricity and the smaller drops bear negative charges. The small drops are blown away or are lifted by the rising current of heated air into the cloud top, where negative electricity collects. The earth also is usually, but not always, negatively charged. When sufficient difference of electric potential has developed, possibly millions of volts, lightning passes between two oppositely charged clouds or from a cloud to the earth (Fig. 45). The passage of the lightning requires only a small fraction of a second. The high temperature of the electric flash heats the air through which it passes, causing a terrific expansion

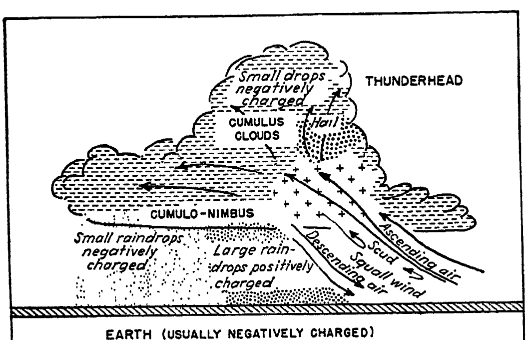

FIG. 44. Diagram of a theoretical thunderstorm. Warm unstable air, filled with moisture, ascends while cooler, more stable air descends; between the two, squall winds and hail result from extreme turbulence. The advancing "head" of the storm consists of low-lying dark cumulonimbus storm clouds, cumulus clouds at a higher level, and light-colored rounded masses of cloud at the highest levels.

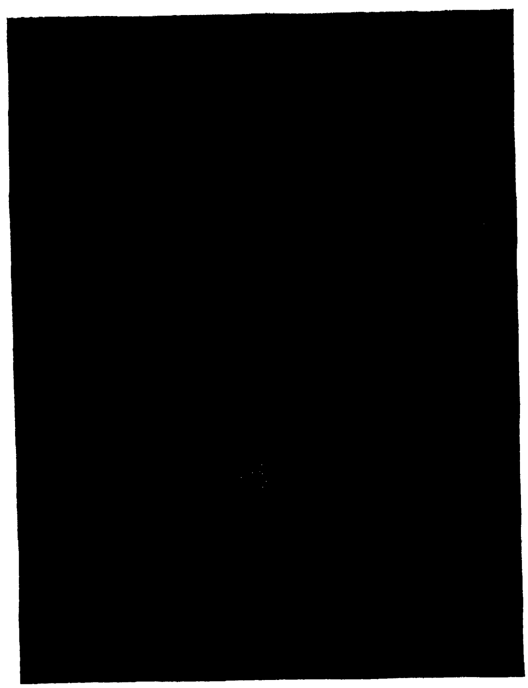

FIG. 45. Lightning strikes the Empire State Building, New York, N.Y. (*Photograph by Lt. Eldridge, courtesy of the U.S. Weather Bureau, Department of Commerce.*)

of the gases, which produces the noise called *thunder*. Reflection of the sound waves on clouds and other surfaces causes the reverberation of thunder. Heat lightning is only the reflection of distant lightning on clouds.

Thunderstorms may be accompanied by torrential local rains or cloudbursts. At other times the lower air may be so dry that the falling rain is almost evaporated before reaching the ground. Lightning in such cases sets many forest fires, especially in the mountains of the Pacific Northwest. A series of local lightning storms that furnished little rain has been known to set over 200 fires in one national forest in Idaho. Lightning may injure trees by suddenly changing the sap to steam, splitting the timber and reducing a tree to kindling wood. Wind may blow into thunderstorms and around them with gale violence, causing damage to property. A special danger comes from the outrushing squall of cold air preceding the storm. Thunderstorms may have great turbulence because of the rapid rise and descent of air currents. This makes the thunderstorm dangerous to aircraft, especially dirigibles, which are not built to withstand strong stresses in opposite directions.

Tornadoes and Hurricanes. Tornadoes are commonly experienced in level country like the Mississippi Valley, especially during spring and fall seasons. Tornadoes usually have wind velocities exceeding 100 miles per hour and may attain a wind force of 200 or 300 miles per hour. Large differences of pressure within short distances account for the high velocity. These storms have a funnel shape. Near the storm center, trees, houses, and other structures may be almost completely destroyed (Fig. 46). Fortunately such storms are small—usually less than a mile wide—and rarely travel more than a few score miles before disappearing. Tornadoes most often develop in advance of the wind-shift line of strongly developed cyclones, that is, near the contact of warm and cold air masses.

Hurricanes generally occur near the borders of the tropics. These storms have the area of

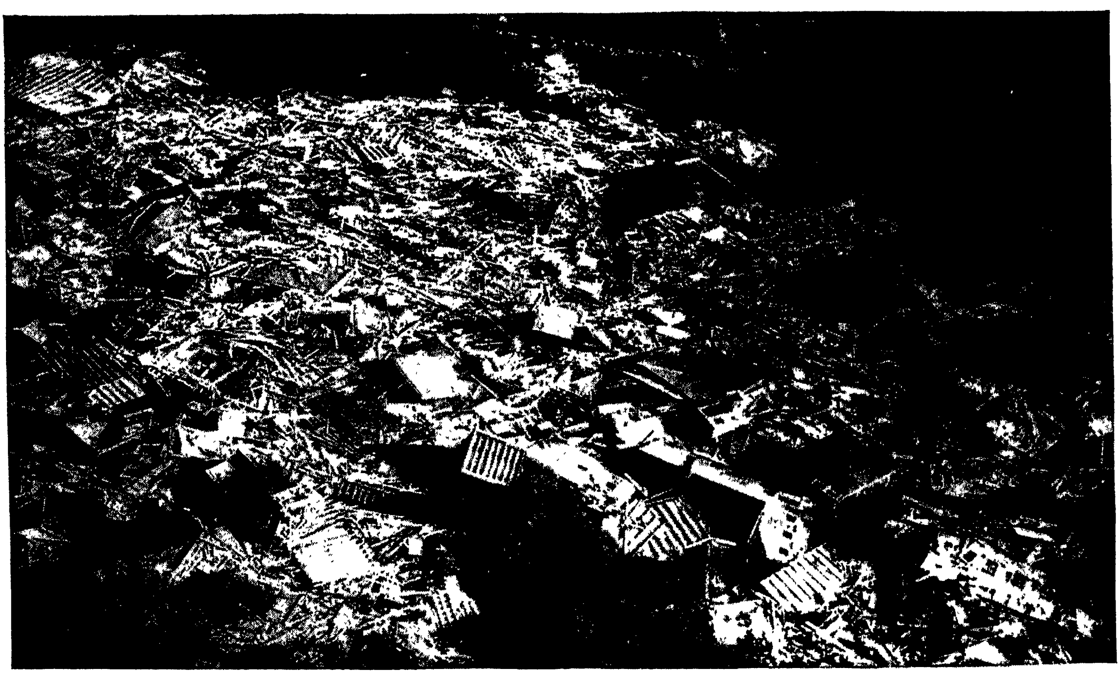

Fig. 46. Hurricane damage in New England, September 22, 1938. (*Photograph by Worcester Telegram, Worcester, Mass. Courtesy of the U.S. Weather Bureau, Department of Commerce.*)

cyclones with a destructive force approaching that of tornadoes. Wind velocities may exceed 100 miles per hour. Hurricanes, or tropical cyclones, most frequently develop in summer and fall. Then much warmth and moisture have accumulated in the tropics and the air in higher latitudes has cooled off with the retreating sun, giving rise to the unstable conditions that create hurricanes.

When hurricanes occur off southeastern Asia they are called *typhoons*. They frequently visit the Philippines, southern Japan, the South Pacific, and the Indian Ocean. The hurricanes that affect North America commonly originate east of the West Indies, move westward in the trade winds, and sometimes travel northward, striking the Gulf coast or Florida. On low coasts much damage results from high waves and the piling up of ocean water by the wind. The intensity of the storms decreases as they move inland, since the energy decreases with the lessened condensation of moisture. If a tropical hurricane moves northeastward up the Atlantic coast, it becomes a "nor'easter," so named because the wind blows toward the approaching storm center from that direction. In September, 1938, a destructive hurricane struck New England, an unusual occurrence for a section of the country so remote from the tropics.

Hurricanes are accompanied by exceedingly torrential rainfall and cause damage by both wind and flood. After the first attack of the wind, the center, or "eye," of a hurricane is calm. Then, when the storm moves on, the wind returns with renewed violence but from the opposite direction. As with cyclones, the circulation of the winds of hurricanes is counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

Problems

1. How does fair weather in winter differ from fair weather in summer in your locality?
2. Compare the usual winter storm with that of summer in the interior of the United States.
3. Give examples of sudden weather changes you have experienced.
4. What should be included in a description of the weather of your home locality?
5. Compare the weather of another region you have visited with that of your home locality.
6. Why is the weather a frequent topic of conversation?
7. What weather changes have affected human activities within the last few days?
8. What season has the most variable weather in your locality?
9. Name three devices intended to make living conditions comfortable in spite of the weather.
10. Give examples of the effect of weather changes on transportation: airplanes, highways, and railroads.
11. Name some weather proverbs you have heard, and explain their bases.
12. Under what conditions does smoke settle in industrial areas?
13. Why do we associate rain or snow with cyclones?
14. What are some ways by which forecasts made by the U.S. Weather Bureau are useful in your locality?
15. In a cyclone:
    What is the pressure condition?
    Which way is the pressure slope directed?
    Which way will the wind probably blow?
    What weather may be expected in the center?
    Will the wind direction be clockwise?
16. Describe changes of weather to be expected as a cyclone approaches, passes over, and recedes from a locality.
17. Draw a circle about 5 inches in diameter, and on it place the names of the wind and calm zones of the earth.

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CHAPTER 5: *Climatic Regions of the World*

Climate affects men in a multitude of ways and is probably the most important of all geographic factors. It is an important control over the distribution of plant and animal life and in consequence largely determines the industries and activities of man, the foods produced in any given area, and the materials available for shelter and clothing. Climate likewise may act as a barrier to the migration of human, animal, and plant life, and it markedly affects man's health and energy.

The temperatures, rainfall, winds, and weather of the world as described in the preceding chapter, when observed over long periods of time, produce a weather complex that may conveniently be summarized in map form. The isothermal map of the world (Fig. 22) represents the observations and means (averages) of the world's temperatures. An analysis of some of its outstanding features leads to several conclusions.

The Mean Annual Isothermal Map of the World. In general the isotherms as they appear on the world map of surface temperature regions tend to follow the parallels; that is, they trend east and west on the earth's surface. This is to be expected, since the earth's position in its orbit is essentially stable and its axis is constantly tilted in one position, directed toward the North Star at an angle approximately 23½ degrees away from its vertical position. This stability of the position of the axis exposes parts of the globe to the sun's rays with great regularity and (since the earth's surface is curved) controls the angle at which the sun's rays are received at any one point on the earth.

The uniformly high temperatures of the earth's surface, year in and year out, are found in regions of low latitude and low altitude near the equator. This is understandable because it is in this part of the world between the Tropics of Cancer and Capricorn that the earth receives two maxima of solar energy when the sun appears in the zenith twice each year. Furthermore the sun's rays penetrate the atmosphere of these low latitudes directly, thereby providing greater amounts of solar energy than are possible in higher latitudes where the rays are oblique. In the tropical regions, days and nights are nearly always of equal length all year long, thus providing a regularity in the earth's heating which is impossible where seasonal changes of temperature are great.

Similarly, those parts of the world isothermal map which are near the polar regions receive smaller amounts of solar energy. They never observe the sun in their zenith; they have a single period of high insolation when the sun is near the Tropics of Cancer or Capricorn; and the sun's rays that reach them are forced to penetrate a great thickness of atmosphere at low angles. These and other factors explain the reduced amount of insolation and heat that is common to polar regions compared with that of the tropical regions.

The world isothermal map shows a pattern of temperature distribution in relation to winds, particularly in the middle latitudes from 40° to 60°N. and S. Here, where winds from the west blow steadily over the oceans, they tend to moderate the temperatures of the west (windward) coasts of continents. This is noticeable in the Pacific Northwest; the British Isles, France, and the Low Countries; southern Chile, and New Zealand. In contrast, the eastern (leeward) coasts of midlatitudes usually experience higher average summer temperatures and colder winters than the west coasts. This is observable in New England, Korea and northern Japan, and Patagonia.

The slight differences in the temperatures of ocean currents affect the courses of iso-

therms in coastal regions and over the seas. The map (Fig. 179) indicates that the cold Peru (Humboldt) Current flowing northward along the western coast of South America brings below-normal temperatures to the coasts of Peru and northern Chile. Similarly, the cool Benguela Current chills the southwest coast of Africa. The eastward extensions of the Japan Current and the Gulf Stream bring to southern Alaska and coastal Norway temperatures above normal for their latitudes.

The effects of altitude on temperature do not appear on the world isothermal map, for maps of this type are drawn in such a way that the *observed* mountain temperatures are changed to read as though they were at sea level. This practice of "reduction to sea level" provides comparable temperature figures and eliminates the effect of altitude on temperature readings.

The Mean Annual Isohyetal Map of the World. The distribution of the rainfall of the world throughout the year is usually shown on a map by lines that connect places having the same average annual precipitation. These lines are known as *isohyets*. A study of the rainfall of the world (Fig. 47) leads to the following conclusions.

Some effects of ocean currents are apparent on the rainfall map, since the air above warm masses of water is capable of containing relatively large amounts of water vapor. If this air, when it reaches comparatively cold western coasts, is unable to retain its moisture, it provides heavy rain or snow for the land surface. This accounts for the large amounts of rain on northwestern coasts in northern latitudes, for example, on Vancouver Island and in southern Alaska, and in Eire, Scotland, and Norway. On the other hand, cold currents provide small amounts of moist air for onshore locations, as in southwestern Africa.

World rainfall maps show plainly the effect of mountains, for moist air of marine origin forced to rise over mountain ranges provides heavy precipitation in western New Zealand, southern Chile, and northwestern Spain.

It is apparent that heavy rainfall in tropical regions as indicated on the isohyetal map is related to the high annual temperatures of these regions as indicated on the isothermal map (Fig. 22). The explanation lies in the fact that the warm and moist air of the tropics, forced to ascend, cools adiabatically and cannot contain as much moisture at high altitudes as it can hold near sea level. This excess moisture then becomes condensed and falls as heavy rains throughout most low-latitude regions.

Seasonal changes of wind direction, combined with mountains, account for most of the precipitation in the low-latitude monsoon regions. This provides sharp contrasts in the windward and leeward coasts of Madagascar, New Guinea, and other islands, as well as the Malabar and Coromandel coasts of India, and the southern and northern slopes of the Himalayas.

In general, those parts of the earth which lie distant from the seas—that is, the interiors of continental masses outside the equatorial regions—have little access to moisture, and their annual supplies of rain and snow tend to be small. For this and other reasons, the great continents tend to become arid and semiarid in their central parts. This is particularly true of the largest land mass, Asia. In general the interiors of continents receive their maximum rainfall in summer when the continental temperatures are highest and the pressure lowest, a combination that causes some inflow of moist air from the oceans.

High latitudes usually suffer from deficiencies of rain and snow, for air of low temperature normally cannot contain large absolute amounts of moisture and hence cannot provide any large precipitation for the lands.

Temperature and Rainfall in Relation to Vegetation and Climate. Plant life throughout the world is dependent upon supplies of heat and warmth in varying amounts. Isothermal and isohyetal maps are therefore especially significant in understanding the distribution of vegetation, in both type and amount, throughout the world. Rainfall and temperature maps combined provide a rea-

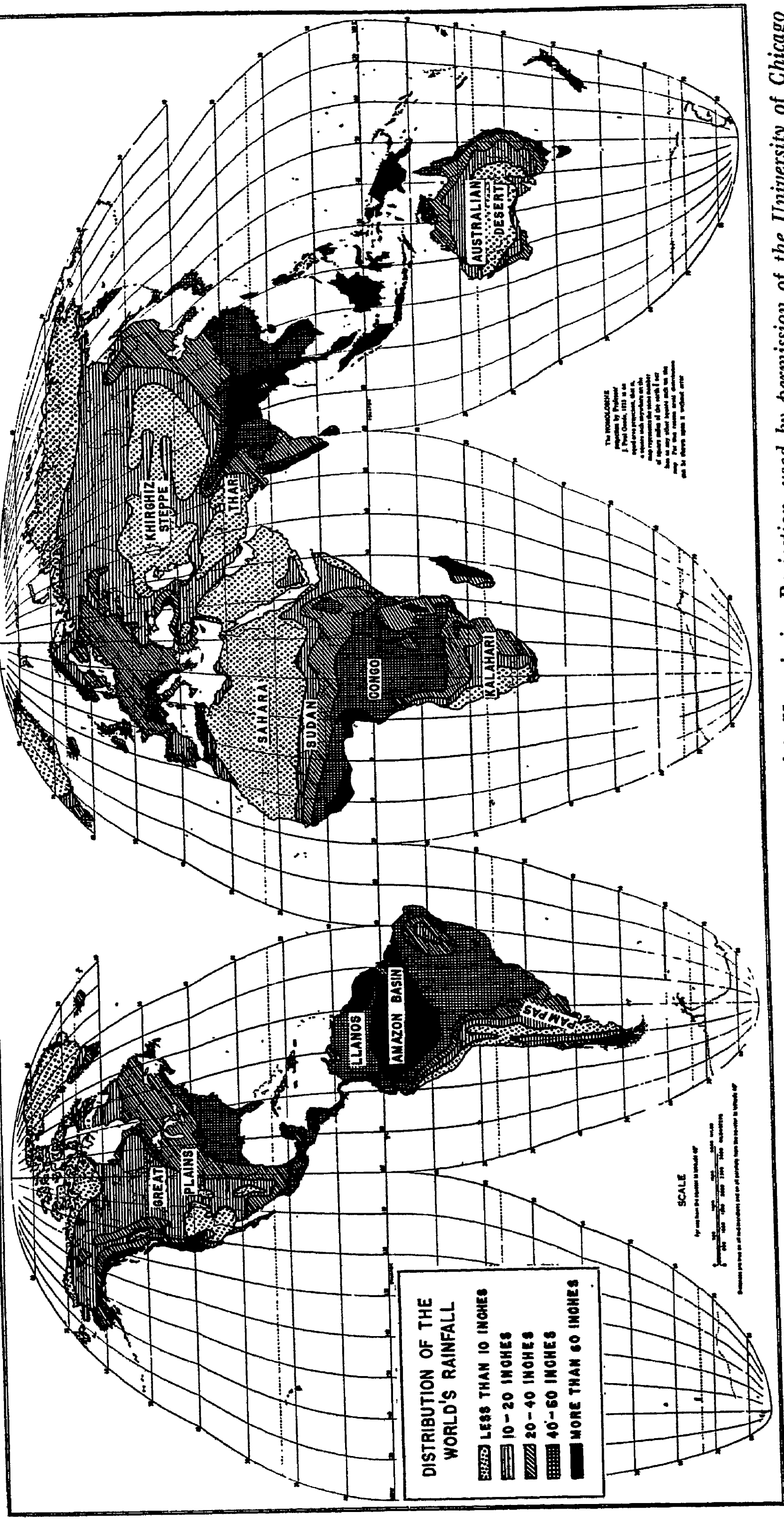

FIG. 47. Distribution of the world's rainfall. (*Base map, The World on Goode's Homolosine Projection, used by permission of the University of Chicago Press.*)

sonably satisfactory basis for the correct interpretation of the vegetation map (Fig. 55).

From consideration of these and other maps, a number of different types of climate, varying in their usefulness to man, have been recognized. Even the ancient Greeks, though their travels were limited, were familiar with some of the climatic zones, and indeed our word *climate* comes indirectly from the Greek.

Human Relationship to Climate. The types of food eaten in different climates by primitive men are mostly those which can be first grown or otherwise secured by hunting, fishing, and gathering. In any case the available food is largely determined by climatic factors. Of course modern transportation allows civilized man to bring food long distances from the climatic regions where it is produced. To maintain good health, man should select different foods under different climatic conditions. His food in the various climatic regions should be of a type and quantity to supply the needed energy without the excess that leads to slothfulness. An Eskimo, who needs foods which furnish much heat and energy, thrives on a diet of blubber and raw meat, but such a diet is wholly unsuited to a resident of the tropics, who does not need food so high in calories.

Deserts serve as an obvious climatic barrier to human activity. Absence of water, lack of food for man and beast, shifting sand dunes, stifling wind-blown dust, and hot desiccating air are trying features of deserts (Fig. 48). In frigid regions the eternal snow and ice, difficulties of travel, and lack of local food and fuel supplies necessitate transporting all required foodstuffs and the means of cooking them. Severe cold taxes the resistance of the body. All these make a strong barrier of cold ice-covered land and water. Difficulties in crossing high mountains are as much due to cold, ice and snow, high winds, and frequent severe storms as to steep slopes and rarefied air. Dense forests, barriers to travel in the Congo and Amazon basins, are a reflection of the hot humid tropical climate of the equatorial zone. The damp heat is most enervating

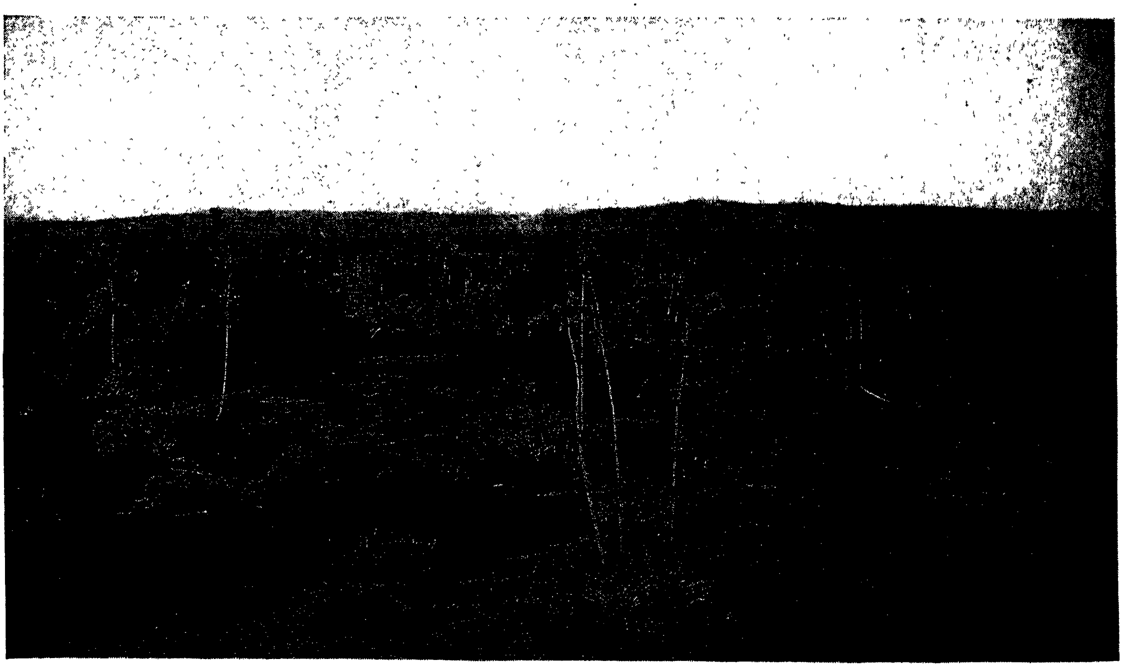

Fig. 48. Desert type of vegetation of the Mojave Desert, California. This represents an environment unfavorable for the support of large numbers of people. (*Photograph courtesy of Robert Pease.*)

to man; diseases are prevalent, and local supplies of food are not always easy to obtain. Tropical forest regions rank high as another example of climatic barriers.

Climate and Energy. Scientific research upholds common observation in noting that weather and climate influence man's health and energy. On hot muggy days human energy is low, and extreme weariness or even exhaustion may result from undue exertion. Dwellers in the humid tropics must work at a slow tempo if they would retain their health, laboring in the relative coolness of early morning or late afternoon with a complete rest, or *siesta,* during the heat of midday. Workers in mid-latitudes should follow the example of their tropical cousins when unusual heat waves sweep over the country in summer. Some of the natives of northern Siberia seem dull and stupid, possibly because their energy is used to maintain body warmth and to obtain the bare essentials of existence in a cold barren environment. Too cold a climate may harm man just as much as life in a hot humid climate.

Everyone has noticed how much better he feels on some days than on others and how much more physical or mental effort he puts forth when weather conditions are favorable. Small frequent changes in weather conditions seem to stimulate man, whereas uniformity of weather, even if not unfavorable, is depressing because of its monotony. Among the climatically favored parts of the world are England, the western mainland of Europe, and much of the United States. These parts of the world are in the region of cyclonic storms and as a result have the small frequent variations in weather that stimulate man to reach his highest mental and physical powers (Fig. 49).

Climatic Changes. Weather factors, especially rainfall, vary in cycles that extend over a term of years. Where the rainfall is barely

FIG. 49. A type of environment that would be comparatively favorable for human activities. This region in Madison County, North Carolina, has been greatly improved by the application of scientific methods of farm practices such as erosion control. The climate is humid and vegetation grows well; winters are not too severe for comfort, and the growing season is long; and timber is at hand for fuel and for building purposes. Streams are large enough to provide water and water power. (*Photograph by the Tennessee Valley Authority.*)

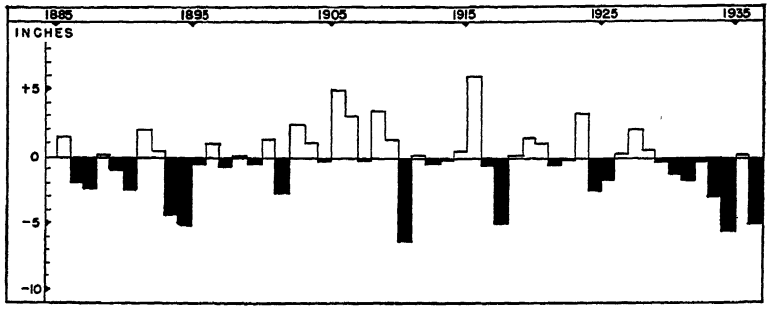

FIG. 50. Departures from normal rainfall over a 50-year period in 12 drought-belt Great Plains states. (Note the succession of years with rainfall deficiency beginning in 1929.) (*After Clements.*)

sufficient for crops or grazing, a decrease in precipitation becomes a serious matter. Crops fail and livestock die of starvation and thirst. Farms, ranches, and trading settlements are abandoned and the inhabitants compelled to migrate in search of new homes. On the Great Plains of the United States since their settlement about 1870, cycles of wet and dry years have alternated (Fig. 50). During years of increasing rainfall, settlers pushed farther into the semiarid lands. Some established cattle ranches, while others plowed up the grass and planted wheat, corn, flax, and hay crops. During the dry years that followed, many of the grain farmers were unable to make a living and abandoned their lands. Ranchers who kept livestock had losses from drought but generally succeeded better than the farmers. Then several rainy years renewed agricultural settlement. The influx of settlers during rainy cycles and departure during dry years has occurred three or four times in parts of the Great Plains since their first settlement by white men.

In Norway, Iceland, or Eire, where the climate is quite wet and stormy, farmers are more prosperous during dry cycles when potatoes and other root crops are less troubled with disease, grain matures better, and hay is easier to cure than in the cold wet years. Huntington believes that the Mediterranean region of Europe and parts of Central America were once stormier and that favored civilizations flourished in these subtropical places, since man would be stimulated by the variable weather. Other authorities, however, disagree with Huntington's conclusions and think the climate has changed little or not at all. They would explain the rise and fall of civilization in the subtropics by other factors.

Huntington also has presented evidence in the form of abandoned cities and other works of man, dried-up lakes, dry river channels, and dead forests, for cycles of rainy centuries alternating with dry centuries in central Asia. This he believes would account for the forced migration of natives from such areas, bringing raids and wars for conquest into the better favored lands surrounding the critical area. Again, however, others would say that the rainfall always was deficient and that towns were abandoned because rivers changed their courses, as the Tarim did a few years ago. Towns also are deserted and trees die as soil becomes impregnated by salt. Glaciers that once helped keep the lakes and rivers full may have melted, forcing an exodus of the residents of these towns.

The rings of trees in the mid-latitudes vary in thickness as conditions are favorable or unfavorable for tree growth. In the southwestern United States rainfall appears to be the chief factor affecting the annual increment of tree growth. Tree rings of the great sequoias, or "big trees," of California furnish a record of 3,000 years of climate, and the yellow pines of the Colorado plateau date back several centuries. Tree-ring records from the Southwest, collected by A. E. Douglass and

his coworkers, certainly show the existence of a short cycle of wet and dry years and probably a long cycle of centuries in length. Douglass and his assistants have been able to date the building of certain Indian pueblos in the Southwest by cleverly correlating the tree rings of living trees with those in the timber used in some Indian dwellings.

Classification of Climate. Various schemes have been used in the classification of climatic types. Based on rainfall, climates may be rainy (humid), dry (arid), subhumid, and semiarid. They may have uniform rainfall, or well-defined wet and dry seasons. Near the poles the most obvious change throughout the year is that of the long day and long night; climate in those latitudes might be based on light and darkness. A better scheme uses actual temperatures or vegetation types. Sometimes temperatures and resulting plant life are combined in classifying climates. An old and very general system of classification is based on temperatures in different latitudes: tropics, subtropics, temperate, subpolar, and polar zones. This plan views the tropics as continuously hot; the subtropics with long summers and short mild winters; the temperate zones with four seasons—hot summers, cold winters, and spring and autumn of intermediate temperature; the polar zones as nearly always cold with a very short warm season which in the coastal and higher sections is practically absent. Interior regions in high latitudes enjoy summers long enough for the growth of hardy trees like birch and conifers; these regions are called the *taiga,* and their climate may be called subpolar. Each of the four generalized climatic zones may be subdivided depending on differences in rainfall, temperature, winds, location with respect to oceans, humidity, and natural vegetation. Sometimes the subdivisions result from the location of high mountains and plateaus.

The classification of world climate adopted for this text depends primarily upon the latitude, the general circulation of the winds, the natural vegetation, and the relationship between land and sea. In general, temperatures on the earth follow parallels of latitude roughly; yet the oceans have smaller ranges of temperature than continents, since bodies of water both heat and cool more slowly than land. Winds flowing inland from the sea, especially where a warm current may adjoin the shore, cause modifications in the type of climate on windward coasts. Thus Sitka, Alaska, has about the same mean annual temperature as Washington, D.C. (Figs. 51 and 52). Northwestern Europe has mild winters because of the Gulf Stream and winds flowing inland from the Atlantic Ocean. On the other hand, the interiors of large continents like Asia have extreme ranges of temperature. The coldest absolute temperatures recorded on the earth's surface have been observed at Verkhoyansk in northern Siberia, where the January temperature averages nearly −60°F., with the absolute minimum falling to at least −90°F.! (Fig. 53).

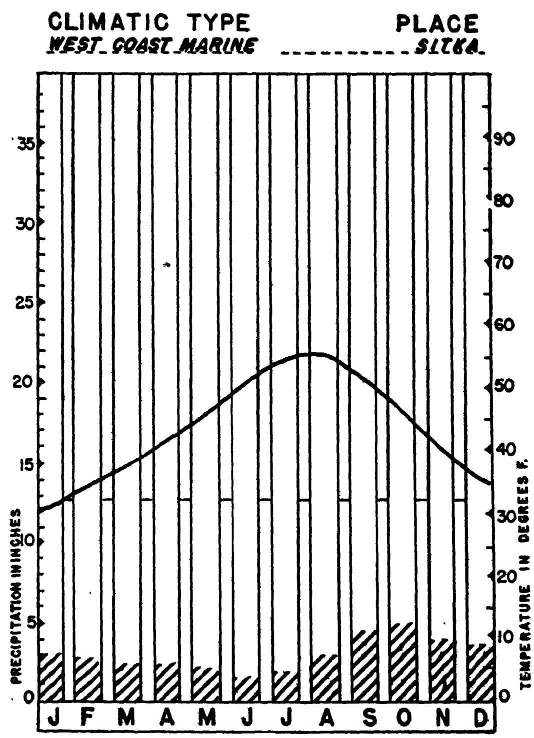

FIG. 51. Climatic graph. Sitka, Alaska.

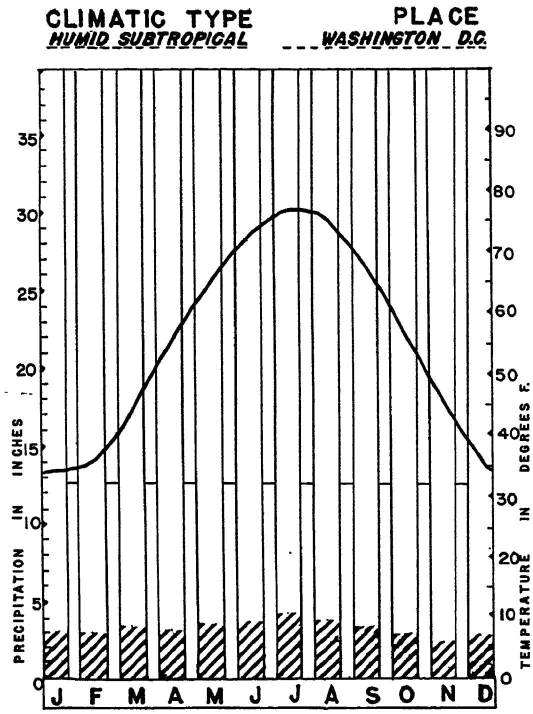

FIG. 52. Climatic graph. Washington, D.C. Washington, 38°55′N., and Sitka, 57°3′N., are separated by nearly 20 degrees of latitude, but the graphs indicate that their winter temperatures are nearly the same. Even their rainfall is similar in amount, but Washington's lower latitude shows plainly in its higher summer temperatures.

Relation between Climate and Winds. Certain types of weather are expected in the different wind zones, although local conditions may cause much variation from the usual climate. Near the equator, when an excess of sun radiation occurs, heat radiation from the earth in turn causes the air to rise. On rising, the air cools by expansion and the abundant vapor contained is condensed, producing clouds and copious and frequent rains. On the other hand, the trade winds, when they blow across plains or plateaus, are drying winds. They blow toward the equator, a warmer region than their source, become heated, and absorb moisture through evaporation, thus causing tropical deserts like the Sahara. But when the trade winds blow across oceans and then are forced to rise over mountainous coasts, as in Madagascar, the West Indies, and the Hawaiian Islands, they produce very heavy rainfall, since the rising air expands and cools adiabatically, causing condensation of the abundant moisture secured by evaporation from the sea. In the horse latitudes the air is in general descending and being warmed by the resulting compression. More water vapor can be contained without

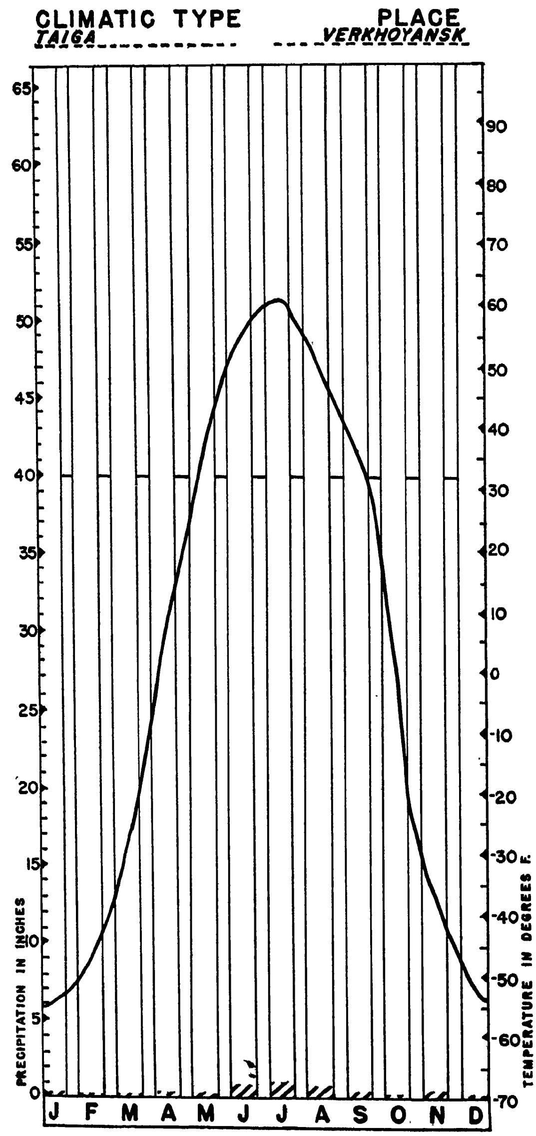

FIG. 53. Climatic graph. Verkhoyansk, Siberia.

condensation, and as a result the horse latitudes have little rain.

In the prevailing westerlies, west coasts of the lands have abundant rain and low range in temperature, while the interiors of continents have little rain and extreme ranges of temperature. This is especially marked when a mountain range on the west shuts off oceanic influences, as in the case of the Cascade Range. On east coasts the climate is usually rainy but with a considerable range of temperature, though not so great as in the interior. The vegetation changes across a continent in the westerlies are evidence of the climatic changes, since forests on the rainy west coast are replaced by grasslands (steppes) and desert plants in the interior, changing to hardwood and mixed forests on the east coasts.

The shifting of the wind belts causes border or transition types of climate. Thus about 8° to 15° on either side of the equator are the savannas, a grassy and open woods country, with summer rains when the equatorial calms shift there but with winter drought when the trade winds shift toward the equator with the movement of the doldrums to the other side of the "line." The Mediterranean climate with dry summers and rainy winters occurs on west coasts about 25° to 35° from the equator. In summer the trade winds blow off the coast and produce drought, but in winter the prevailing westerlies and their associated cyclonic storms shift toward the equator and bring rain. Coastal southern California enjoys this type of climate.

Poleward from the prevailing westerlies the summers are shorter and winters lengthen. Here a coniferous forest (taiga) extends in a zone around the world, in the Northern Hemisphere. Beyond the limit of tree growth lies the tundra, represented by the "barren grounds" of northern Canada, where the ground below the surface is frozen permanently and only moss and other scanty herbage grow. The higher lands in the polar zone are occupied by permanent ice caps.

In general, the position of actual climatic regions depends much on whether winds flow from the sea to the land or vice versa. In the trades the rainy regions extend farther from the equator on the windward (east) coasts than on the leeward (west) coasts. In the westerlies the west, or windward, coasts have a much broader extent of moderate climate than on the east coasts. Hence the boundary between the so-called "temperate" and subpolar zones traverses North America from the northwest in Alaska rather south of east toward the Atlantic. High altitudes may locally cause colder climates than their latitude warrants.

In this text, climates are classified as follows:

1. Wet equatorial
2. Wet and dry tropical
   a. Savanna type
   b. Monsoon type
3. Dry tropical
   a. Trade-wind desert
   b. Steppe
4. Mediterranean
5. Humid subtropical
6. West-coast marine
7. Dry continental
   a. Steppe
   b. Desert
8. Humid continental
   a. Interior
   b. Modified east-coast marine
9. Subpolar continental (taiga)
10. Tundra
11. Polar ice caps
12. High altitudes

Geographers and climatologists have not agreed upon any single system of climatic classification, principally because of confusion concerning the locations of the boundaries of the different climates. In the main, however, they are in agreement on the locations of the great areas of tundra, monsoon, and desert regions. Consequently the student should consider most climatic boundaries as zones of change or transition between climates rather than as the sharp lines that are indicated on maps. Few climatic boundaries are sharply defined except along the crests of high mountain ranges.

The distribution of the principal climate zones used in this volume is shown in map form as Fig. 54. At first glance the map seems to have no discernible pattern, but as the student becomes more familiar with the climatic distinctions of the different parts of the world, he will find the principal areas fitting into their proper places in the light of the discussion in the chapters that follow. Some climatic classifications used by other geographers are included at the end of this chapter for purposes of comparison.

Climatic Classifications

Jones and Whittlesey [1]

Low Latitude Types
1. Rainy low latitude
2. Low latitude wet and dry
3. Low latitude semi-arid
4. Low latitude desert

Middle Latitude Types
5. West margins continents (lower middle latitude)
6. East margins continents (lower middle latitude)
7. West margins continents (higher middle latitude)
8. Humid continental with long summers
9. Humid continental with short summers
10. East margins continents (higher middle latitude)
11. Middle latitude desert
12. Semi-arid middle latitude

High Latitude Types
13. Lower high latitude
14. Subpolar
15. Polar

Bengtson and Van Royen [2]

I. Tropical Climates
- A. Rainy
- B. Savanna
- C. Highland
- D. Steppe
- E. Warm Desert

II. Subtropical Climates
- F. Dry
- G. Humid

III. Intermediate Climates
- H. Short cold winter etc.
- I. Long cold winter etc.
- J. Modified Continental
- K. West Coast Marine
- L. Subpolar
- M. Middle Latitude Steppes
- N. Middle Latitude Deserts

IV. Polar Climates
- O. Tundra
- P. Icecap

V. High Altitude Climates
- Q. Mountains

White and Renner [3]

I. Tropical Zone
1. Rainy
2. Monsoon
3. Semi-arid
4. Arid

II. Subtropical Zone

5. Mediterranean
6. Humid
7. Dry

III. Cyclonic Zone

8. Humid Continental—long summer
9. Humid Continental—medium summer
10. Humid Continental—short summer
11. Dry Continental
12. Temperate Marine

[1] From "An Introduction to Economic Geography," by Wellington Jones and Derwent Whittlesey. Used by permission of the authors and of the publisher, University of Chicago Press, Chicago, 1925.

[2] Reprinted by permission of Prentice-Hall, Inc., from "Fundamentals of Economic Geography," revised, by Bengtson and Van Royen. Copyright. 1935, 1942, by Prentice-Hall, Inc.

[3] From "Human Geography: An Ecological Study of Society," by C. Langdon White and George T. Renner. Used by permission of the authors and of the publisher, Appleton-Century-Crofts, Inc., New York, 1936 and 1948.

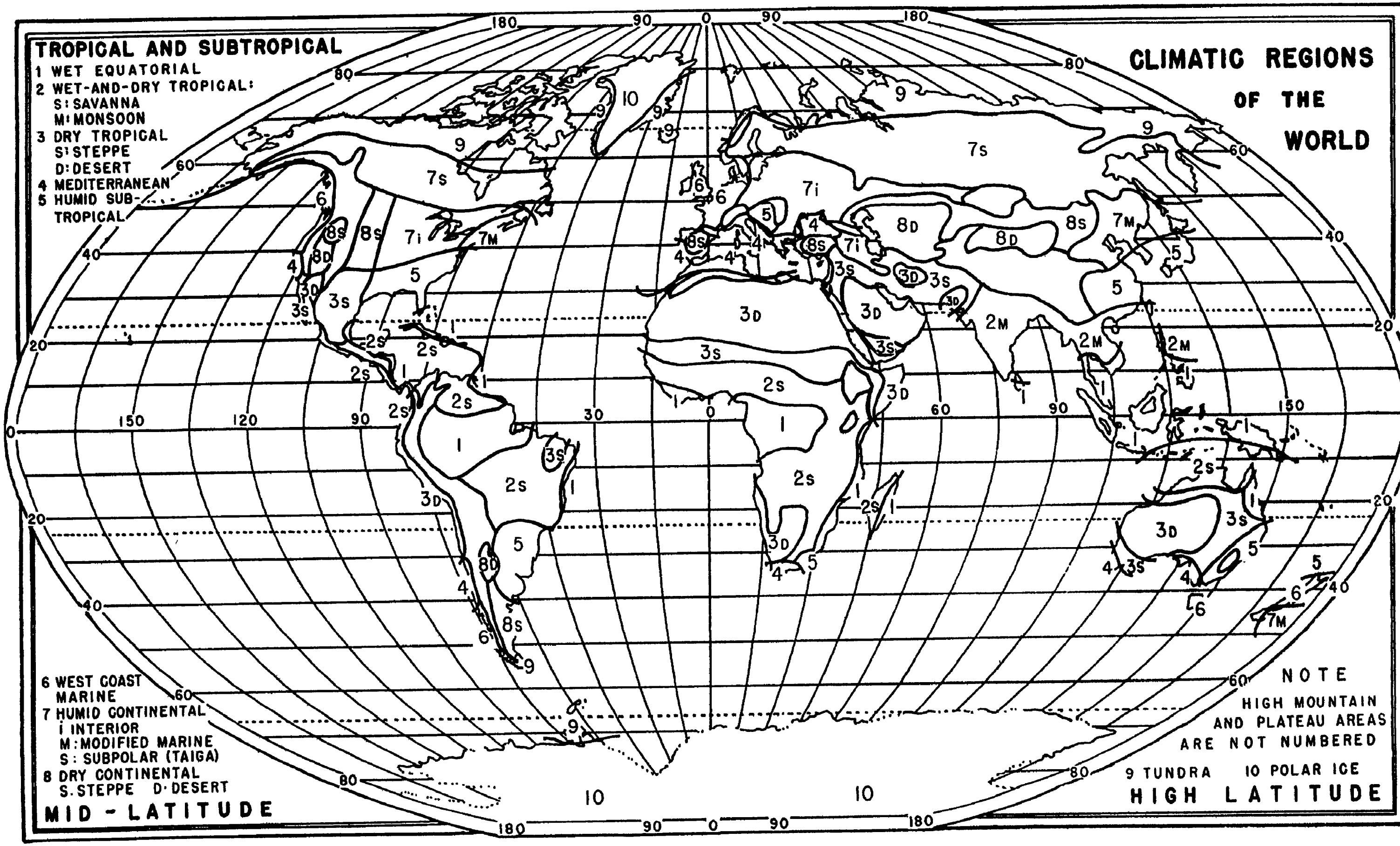

FIG. 54. Climatic regions of the world. (*Denoyer Semi-elliptical Projection. Copyright. Courtesy Denoyer-Geppert Company, Chicago.*)

IV. Polar Zone
  13. Subpolar
  14. Polar Icecap
V. Unclassified
  15. Highlands, climates variable according to altitude

Trewartha[4]

I. Tropical Rainy
  1. Rain Forest
  2. Savanna
II. Dry Climates
  3. Tropical and Subtropical Steppe
  4. Middle Latitude Steppe
  5. Tropical and Subtropical Desert
  6. Middle Latitude Desert
III. Humid Mesothermal Climates
  7. Mediterranean or Dry Summer Subtropical
  8. Humid Subtropical
  9. Marine West Coast
IV. Humid Microthermal Climates
  10. Humid Continental, Warm Summer
  11. Humid Continental, Cool Summer
  12. Subarctic
V. Polar
  13. Tundra
  14. Ice Cap

Köppen

I. Tropical Rainy
  Af. Tropical Rain Forest
  Am. Monsoon
  Aw. Tropical Savanna
II. Dry Climates
  BWh. Low Latitude Desert
  BWk. Midlatitude Desert
  BSh. Low Latitude Steppe
  BSk. Midlatitude Steppe
III. Humid Mesothermal
  Cfa. Humid Subtropical
  Cfb. Midlatitude Windward Marine
  Cs. Mediterranean
  Cw. Upland Savanna
IV. Humid Microthermal
  Dfa. Humid Continental, long summer
  Dfb. Humid Continental, medium summer
  Dfc. Humid Continental, short summer
  Ds. Midlatitude, dry summer
  Dw. Midlatitude, dry winter
V. Polar
  ET. Tundra
  EF. Ice Cap

Problems

1. What is the difference between climate and weather in a given region?
2. Describe an area with which you are personally familiar, discuss its landscape in relation to its climate, and note those geographical items which give it distinction.
3. Assume the presence of a continental land mass in the Northern Hemisphere extending from 35° to 50° latitude. No mountains are involved in the problem.
   a. What climatic influence would affect its southeastern coast?
   b. Describe weather conditions on its western coast from 40° to 50° latitude.
   c. How would these conditions differ from the east coast in the same latitude?
4. High mountain ranges are interposed at right angles to the prevailing wind direction in each of the following locations:
   a. In the zone of southeast trade winds. Which side of the mountains will probably receive heavy precipitation?
   b. In the prevailing westerly winds of the northern hemisphere. Which side of the mountains will be unlikely to need irrigation?
   c. In the monsoon zones of southeastern Asia. Which will be the windward side?
5. Heavy rainfall in tropical lowland regions near the equator is related to the time when the sun's rays are most nearly vertical, but the vertical rays of the sun migrate from the Tropic of

[4] From "An Introduction to Weather and Climate," by G. T. Trewartha. Used by permission of the author and of the publisher, McGraw-Hill Book Company, Inc., New York, 1943.

Cancer to the Tropic of Capricorn and back each 12 months. What then happens to the zone of heavy rainfall associated with the vertical sun?

6. What would be the effect on the climate of North America of (*a*) removal of Coast Ranges, the Sierra Nevada, and Cascade Mountains, (*b*) location of a high mountain system north of the Gulf of Mexico?

7. What would be the probable effect on the settlement of Brazil if the broad part of South America were shoved 2,500 miles southward? In what wind belt and climates would the country then be located?

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CHAPTER 6: *The Geography of Plant and Animal Life*

Plants and Their Distribution

The vegetation types found in any given area are the inevitable result of the action of the natural environment upon the plant forms that are native to the region, with some plants added through the interference and intervention of man. The study of plants in relation to their environments is known to the botanist as *plant ecology*. In regions where man has not greatly destroyed or modified the natural vegetation, the plants form a most obvious part of the environment (Fig. 55). In general they reflect quite closely the sum total of all the environmental factors: rainfall, sunshine, length of growing season, temperature, frost, soil, mineral content of the ground, drainage, windiness, and other things. Water, light, and heat are especially important factors affecting plants. That the appearance of plants is a reflection of environment is proved by the fact that, given the same climate, soil, and other natural factors in widely separated parts of the earth and with practically none of the plants belonging to the same species, the general appearance of the vegetation attains a marked resemblance in widely separated regions. Thus the savannas in Africa, South America, or Australia are similar in general aspects, and the rain forests of the Amazon Basin resemble those in rainy equatorial lowlands elsewhere, although the trees are of different species.

Classification of Plants. Plants may be classified in many different ways. To the geographer the exact species is less important than the way in which a plant reflects natural environmental conditions. With reference to size, plants are divided into trees, shrubs, and the succulent grasses and herbs. Another scheme of classification groups plants by their relative resistance to drought: *xerophytes,* those most able to exist under drought conditions; *hydrophytes,* those which thrive under wet conditions; and *mesophytes,* those which grow under conditions of moderate moisture supply. Plants differ in their ability to grow in sunshine or shade. Another method of classification groups them according to susceptibility to frost and ability to withstand the cold of winter and short growing seasons. Casual observation shows that plants differ depending upon whether soil is well drained or waterlogged, whether it is high in content of soluble plant food or poor and leached, and whether it is impregnated with salt and other alkalies or free from such minerals.

Plant Associations. The same type of plant may not always persist in the same localities. Plants occur in groups or associations, but after one association has occupied the ground a different association usually succeeds the first. To illustrate, in the northern Rocky Mountains, following a forest fire, the first plants to occupy the ground are those with air-borne seeds like the fireweed and other quick-growing herbs, but the first tree is nearly always the lodgepole pine, whose pitchy cones are so firmly held on the tree that excessive heat is needed to release the seeds. Soon the first annuals and other short-lived plants are crowded out by the growing pines, under whose cover the seeds of the lodgepole pine itself will not germinate. Because some trees grow better in shade, the larch and certain firs or the white pine form the association that normally follows the lodgepole-pine forest. When the ground is thoroughly shaded and covered with humus and other partly decayed plant matter, the

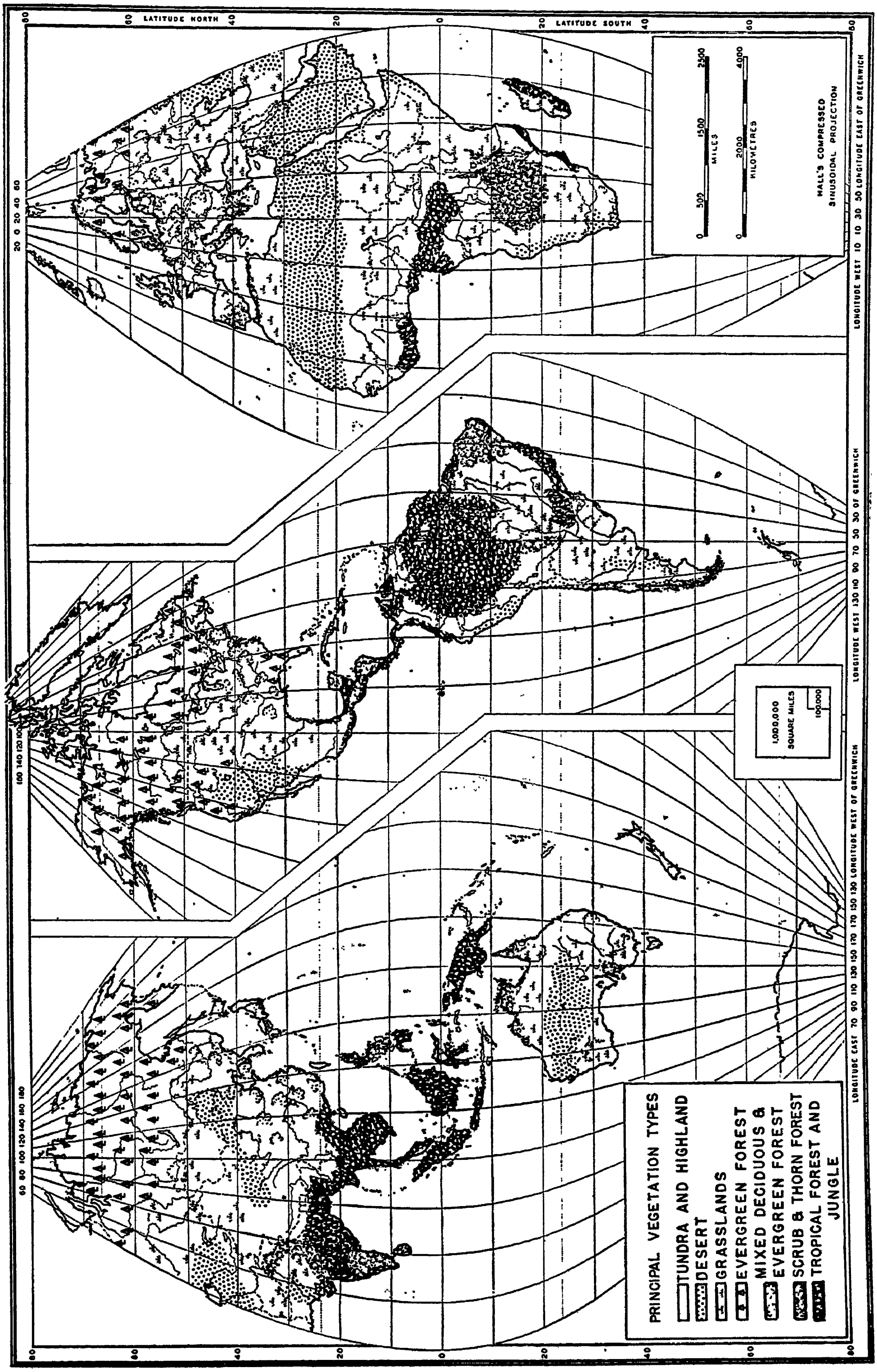

FIG. 55. Principal natural vegetation types of the world. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

seeds of most trees are kept from germinating. The cedar and western hemlock will develop under those conditions, however, and they therefore constitute the culminating, or climax, association.

Thus, after a lapse of many years, perhaps centuries, the forest in any one place reaches its climax, that is, an association made up of those trees and other plants which can thrive best under the sum total of all dominant environmental conditions. Trees forming the different sorts of plant associations may be of unequal value to the lumberman. Thus Douglas fir, coming early in the development of forests in western Washington and Oregon, is more valuable than the western hemlock and other trees that form the climax association. In the southern Great Lakes region of this country, the climax forests may be beech and maple trees that can stand dense shade, among existing conditions, or they may be other trees under another set of factors. The problem of the forester is to endeavor to encourage the reproduction and perpetuation of the more valuable species whether or not they are the normal ones to be expected in the climax association.

Each of the great climatic regions of the world has its own types of vegetation or plant associations. Thus in the tropics the wet equatorial regions support a tall, dense rain forest, or *selva,* which has considerable undergrowth and multitudes of climbing vines (lianas) together with *epiphytes* (air plants) and parasitic plants. The wet-and-dry tropical regions have open woods, shrubs, and grass, called savannas. The trees usually are rather short in growth habit, compared with those of the rainy tropics. Often the grass is very tall, like the elephant grass of the southern Sudan, reaching 10 feet or more in height. The tall grass in the mid-latitudes is spoken of as *prairie land,* or *prairies.* The short-grass areas that reflect semiaridity are called *steppes,* whether in the wet-and-dry tropics or in a continental interior region of very cold winters.

Environmental Factors. A great many environmental factors must be considered before there can be a satisfactory understanding of the development of a given plant association. The plant complex in an association depends upon the particular local values of temperature, rainfall, soil permeability, soil fertility, length of growing season, depth and duration of snow cover (in middle and high latitudes), altitude, wind direction and velocity (in the case of air-borne seeds), intensity of sunlight, temperature or heat, and many other items. Some of these values, like amount of rainfall and temperature, can be estimated or observed with little difficulty; others have less positive effects upon plant life and are more difficult to assess. One of the most important determinants of a plant association is the type of exposure. In the Northern Hemisphere, for example, certain types of plants require a southern exposure for their best development; others cannot tolerate the intensity of sunlight, evaporation of moisture, and other conditions associated with southern exposure. This accounts for the wide variation in plant associations that may be seen on the southern and northern slopes of southern California mountains, in a semiarid climate. The contrasts are usually less clearly marked in humid climates.

Conditions for Forests. Forests, for their best development, require plenty of rain, preferably without prolonged droughts; a fairly long frost-free growing season; reasonable soil drainage; and absence of continuous strong winds. Long droughts are very hard on trees and kill great numbers of them. When subjected to a well-defined wet-and-dry climate, trees generally shed their leaves during the dry season and are modified in other ways in order to conserve plant moisture. The limit for poleward tree growth seems to be determined as much by the very cold dry winds of the long winters of high latitudes as by shortness of the growing season itself. High mountains adjoining arid regions may have two "tree lines"—an upper one limited by cold wind and shortness of growing period

FIG. 56. Timberline trees, principally the bristlecone pine. These trees find it difficult to live in the face of heavy winter snows, high wind, and other inhibiting features of their environment. (*Photographed in Colorado by Dr. E. C. McCarty and used by permission of the U.S. Forest Service.*)

(Fig. 56) and a lower limit determined by lack of rain. Between these extremes, belts of vegetation on the mountainsides reflect the change in climate conditions that results from elevation, just as the much broader belts of vegetation on the lowlands extending from the hot tropical deserts to the arctic wastes reflect climatic conditions resulting from latitude.

Hardwoods and Softwoods. Trees may have broad leaves or needle leaves. In the United States these names are practically interchangeable with the expressions hardwood and softwood. Broadleaved, or hardwood, trees may be deciduous and shed their leaves in the cold season or the dry season, or they may be evergreens when growing in the tropics. Needle trees are usually evergreen except for a few species that shed leaves in winter, like the eastern tamarack and the western larch in this country.

Relation of Plants to Water Supply. In nature plant habitats may vary according to the amount of water available from the salt oceans and fresh-water lakes to the driest rock surfaces in deserts. No plant can adapt itself for living under all these conditions, but each type of plant becomes adapted to a certain water relationship from which it rarely departs. With decreasing dependence upon water, plants are classified as hydrophytes, mesophytes, and xerophytes as previously noted.

Hydrophytes live in ponds, streams, oceans, swamps, and wet meadows. They do not find it necessary to conserve water, and they lack

the plant structure that other plants possess to restrict evaporation. Leaves are usually large but thin, and roots small and shallow. In floating plants the stem may lack supporting fibers. Besides the actual water plants, like algae, rushes, and lilies, the banana is a type of hydrophyte, since heavy rainfall is required for its successful growth.

Two hydrophytic trees are the mangrove and the cypress. The former grows in shallow salt water along seacoasts and on the shores of lakes almost everywhere in the moist tropics. Its habitat is in shallow water where it can put down a tangle of roots resembling stilts, supporting a scrubby trunk above the mud flats. The cypress (Fig. 57) grows in swamps in the southern United States. This tree has curious "knees" that project from the roots above water and probably prevent the tree from being smothered while standing in the water. The cypress supplies us with a valuable commercial timber, because the wood does not decay readily when immersed in water.

Mesophytes include most of our familiar plants like the common trees, shrubs, and herbs that live in intermediate climates of moderate rainfall and temperature. They have no special or extraordinary features that reflect their native environments. The roots are generally numerous and much branched. The foliage shows a heavy development, and the rate of water evaporation stands midway between that of hydrophytes and xerophytes. The areal distribution of mesophytes is limited by their ability to adapt themselves to climatic conditions in which cold or drought may be a principal limiting factor. Corn, for example, is a mesophyte definitely limited by drought; it does not produce satisfactory commercial crops where the supply of rainfall is too low. This condition, however, may be overcome by man, who will plant the corn and provide sufficient water for it by irrigation, as he has done repeatedly in the southwestern United States since prehistoric times. Corn is limited by a second factor, for it has a large capacity for enduring high summer tem-

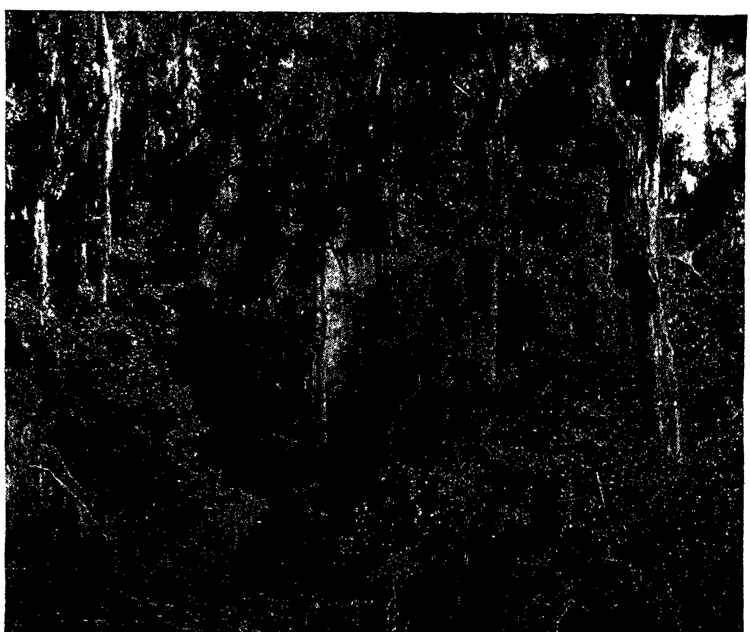

FIG. 57. Live oak and cypress swamp of the humid subtropical region of the southern United States. Little Gum Swamp, Osceola National Forest, Florida. Note the dense growth of vegetation, the Spanish moss, and the hydrophytic vegetation of the swamp. (*Photograph by B. W. Muir, courtesy of U.S. Forest Service.*)

peratures; if the growing season is too short or nights are too cool in summer, corn does not produce a good crop. Unfortunately, man can do little to correct this limitation except to plant his corn in more favorable climatic locations.

Xerophytes live under drought conditions and have developed features that enable them to survive their harsh environment. Some xerophytes escape destruction from drought by developing the ability to complete the life cycle from germination to seed production in such a short time that a single shower may provide enough moisture to complete the process. After maturity the seeds lie dormant until another rain causes germination. This accounts for the flower-carpeted deserts in bloom for a brief period after local showers. Desert plants may evade drought as a result of their small size and their ability to survive with very little water. Other xerophytes become dormant during drought and renew plant activity only when a supply of moisture becomes available. A fourth group resists drought by accumulating water supplies that can be drawn upon during dry seasons; the barrel cactus is an example (Fig. 58). Methods of plant adaptation to a small supply of water include (1) thickening of the tissues, leaving only a small surface from which evaporation can occur, as in the cacti; (2) secretion of oil substances to reduce transpiration further; (3) root systems vastly larger than the plant aboveground, which can gather moisture very quickly when it is available; (4) leaves that are shed in the dry season or turn their edges to the sun or curl up in the heat; (5) leaf surfaces protected against evaporation by fine hairs and the secretion of wax and resins; and (6) leaves modified to moisture-conserving thorns, which have the advantage that they protect the plant from being readily eaten by desert animals.

Light. Light is necessary to plant life because it furnishes the energy for the process of changing water and carbon dioxide into starch by the chlorophyll bodies of the leaves, a process called *photosynthesis* (putting together by means of light). Plants react strongly to light differences. Leaves and stems of plants like the sunflower often turn with the light. Flowers and other parts of the plants open and close with different conditions of light. Some plants in the shade tend to grow tall in order to reach the light, whereas in the bright sunshine the same plants may be low and thick. Excessive light may destroy plant matter if it is too intense, but ordinarily it induces more rapid growth, as in the far north where nearly continuous daylight lasts for several weeks, enabling vegetation to mature in the short growing season. Plants that are shade resistant tend to form the climax plant associations in forest regions, since they germinate and grow to the exclusion of the sun-loving plants. Parasitic plants usually flourish under shade conditions. Bacteria and fungi may multiply so rapidly in the hot humid tropics that they may cause the trunks of fallen trees to crumble into complete decay in a year or two.

Heat. Plants differ markedly in their needs for heat. Each has an upper limit and a lower limit of endurable temperatures and in addition a certain optimum, or most favorable, temperature for growth. Often the finest flavored fruit is grown near the colder limits of heat for the species. Thus many northern-grown vegetables are superior in quality to those coming from warmer parts of the world, and northern-grown garden seeds are preferred by many. Some trees require the stimulus of freezing temperatures before they will live and blossom the next year. Certain peach trees planted in southern California after mild winters were found to produce very inferior crops compared with those which had been exposed to several degrees of frost. If the temperature falls too low, however, many fruit trees and other plants have their blossoms and leaves destroyed, and perhaps the whole plant itself will be killed.

Other Factors of Plant Ecology. Minor factors affecting plant growth include humidity of atmosphere, rate of evaporation, and wind. Wind has a material effect on both wild and

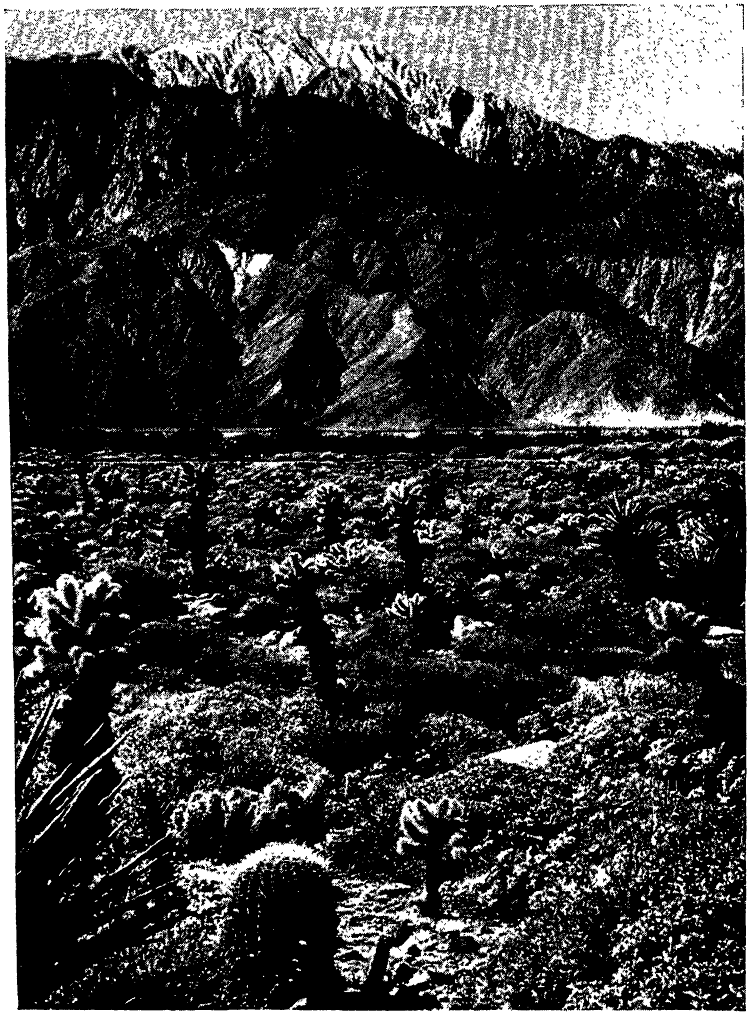

FIG. 58. View of the desert and mountains in the southeastern part of California. Different types of cacti appear in the foreground, of which the largest is the barrel cactus. (*Photograph by Frashers Photos, Pomona, California.*)

cultivated plants. Sometimes windbreaks are used to protect growing plants from injury by strong and hot dry winds. Tree growth may be limited or stunted on mountains or seacoasts that are exposed to severe wind conditions. Excessive evaporation may injure plants, since the amount of water available for the plant may be insufficient to replace moisture as rapidly as it evaporates. Hot dry winds may therefore do much damage to growing crops in exposed locations. In the citrus groves of southern California, occasionally a hot wind known as the *Santa Ana* is greatly dreaded by the ranchers because it whips the leaves of trees against the fruit, thus damaging its appearance and market value. These strong winds, which may reach velocities of 75 miles per hour, blast the orange blossoms, turn leaves brown, break branches, and sometimes ruin an entire season's crop of fruit. For this reason, tall windbreaks of cypress, eucalyptus, or other trees are planted around many citrus groves to protect against high winds of low humidity and damaging force.

Soil is a major factor influencing plant

growth. The relation of soil to plants will be discussed in a following chapter.

Plants as Environmental Indicators. Since every plant is the product of the conditions under which it grows, plants oftentimes provide a good indication of the occurrence of ground water, type of soil or subsoil, the climate, and other factors of environment. Plants may indicate both natural conditions of environment and the use to which land may be put. The presence of bulrushes and cattails indicates saturated conditions of the soil and consequent poor aeration. Greasewood and other *halophytes* (salt-tolerant plants) indicate the existence of alkali in the soil. Ginseng, maple, hemlock, cedar, and many other plants are tolerant of shade and indicate low light intensity. Cottonwood, willows, and mesquite indicate that ground water is fairly close to the surface. Settlers on cutover land in northern Michigan may prosper on land that supported beech and maple trees, indicators of fertile soil; but they seldom succeed on land where pines indicate poor soil.

Tall-grass prairies have abundant humus in the soil, coming from the stems and roots of decaying grass. Thus the grasslands are retentive of soil moisture and highly productive for agriculture, especially when planted to grains. Areas of scattered bunch grass store less moisture in the ground and as a rule indicate an average annual rainfall of less than 20 inches. Such lands can be used for farming only with care, and much damage has resulted from overgrazing and careless farming on such grasslands. Soils of both dry grassland and deserts originally covered with sagebrush and cactus may be highly productive when irrigated, but the presence of desert vegetation is an indicator that this land should not be used for farming without irrigation. When areas are overgrazed, the good fodder grasses—bluestem, grama, and wheat grass—decrease, and an increase occurs in the inedible or undesirable plants like the prickly pear, thistles, sagebrush, various weeds, and the quickly maturing grasses like cheat grass. In forest areas overgrazing may prevent natural reproduction of the trees.

Relation of Plants to Climatic Areas. *Rainy Tropical.* Vegetation reaches its maximum development in tropical regions where the conditions of temperature and moisture are favorable to plants. Extraordinarily rank vegetation grows in the tropical rain forests of the East Indies, Amazon Valley, and Congo Basin. Uniform high temperature, steady and heavy rainfall, and sufficient minerals left in the soils in spite of excessive leaching combine to produce dense forests of giant trees supporting tangles of creeping and climbing vines and epiphytes. Unless the shade is too dense, a tangle of undergrowth, ferns, and other shade-resistant plants carpets the earth. If the shade is very dense, these ground-loving plants are reduced in numbers. A wealth of palm trees, wild bananas, banyan, rattan, tree ferns, mahogany, ebony, and other hardwoods and dyewoods occurs intermingled in an extraordinary way. The palms are perhaps the most characteristic tropical tree (Fig. 59). Hundreds of species of palm trees exist, and they are among the most useful trees in the world. Those in the rainy tropics furnish oil from their nuts and seeds. The natives of Malaysia chew betel nuts instead of using plug tobacco. The leaves, living crown, sap, and wood of the palm all provide needed materials to the natives.

Many trees and vines furnish a latex from which rubber can be made, and one of the trees, the *Hevea* of Brazil, is cultivated in plantations. The cacao tree furnishes the chocolate and cocoa of commerce and is a native of the hot steaming jungles. The most characteristic flowering plants are the epiphytes like the orchids, which flourish wild and in incredible numbers in the tropical rain forests. The mangrove in the salt marshes and the coconut palm on the sandy beaches are characteristic tropical plants in their special environments. The strand line of the Pacific Islands affords a home for the pandanus, or screw pines, whose leaves are used for weaving of mats.

FIG. 59. Subtropical palms lining a drive as ornamental plantings in a Mediterranean region.

The Dry Tropics. The tropical forests and jungles that develop with abundant rainfall merge into the tropical shrub, open woodland, and grass of the savannas. In Africa typical trees of the wet-and-dry tropics are the acacia and baobab, the latter having huge ungainly trunks and wide-spreading limbs free of leaves in the dry season. Various types of acacias, drought-resistant palm trees, and certain deciduous trees and shrubs also occur. In Australia hardy eucalyptus types like the mallee give way to the acacia as the desert is approached. In the deserts drought-resistant shrubs, herbs, and grasses predominate and are joined in rainy seasons by quick-blossoming flowers and quickly maturing grasses.

The Mid-latitudes. The Mediterranean regions have drought-resistant forests characterized by narrow leathery-leaved plants, many of which are deciduous, shedding their leaves in the dry season rather than in winter. The cork oak of the western Mediterranean, and the live oak of California form extensive open park-like woods. In other places various cedars, certain pines, cypress, and varieties of palms flourish. In Australia, scores of eucalyptus trees, wattle trees that belong to the acacia group, and other plants of that nature grow in forests and open woods.

In mid-latitudes the deciduous forests develop in a climate of warm rainy summers and cold snowy winters which characterizes the seasons on the east coasts of continents and inland for some distance. The west coast in the same latitudes supports conifers similar to those found across the entire Northern Hemisphere, through northern Europe, Asia, and North America. Generally the coniferous forests contain few species compared with the deciduous forests. The fact that stands of timber contain only a few species greatly favors the development of a lumber industry. The largest trees in America and probably on earth are two varieties of sequoia, the redwoods of the northwest coast of California (Fig. 60) and the "big tree" of the Sierra. The redwoods grow from central California to Oregon only in a narrow belt of 20 to 30 miles in width where the summer heat is tempered by Pacific fogs. They do not grow so close to the coast that they are fully exposed to sea winds, for their great bulk and height would make them susceptible to damage by high winds. The sequoia "big trees" occur in scattered groves on the western middle slopes of the Sierra Nevada at elevations of from 5,000 to 8,000 feet. Some of these trees have diameters of nearly 40 feet. The huge Douglas firs and cedars of the Puget Sound region approach the size of the redwoods and form some of the best commercial timber stands on earth. Needle-leaved conifers of the genus *Araucaria* occur in South America and in New Zealand and other Pacific islands, but true conifers are restricted to the Northern Hemisphere.

The Cold Regions. Poleward from the coniferous forests, the tundras and polar des-

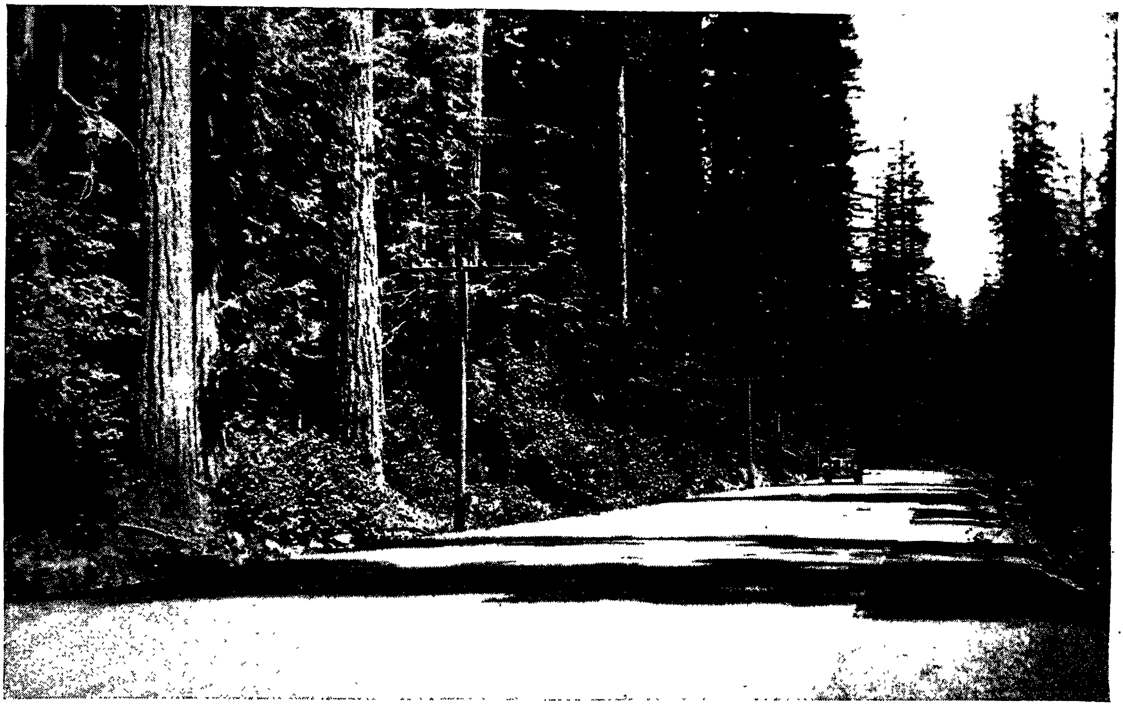

FIG. 60. Groves of coast redwoods (*Sequoia sempervirens*) line the Redwood Highway in the Coast Ranges south of Humboldt Bay, California.

erts occur. Bogs are common in both the coniferous forests and the tundra. The northernmost forest belt consists of a mixture of larch, pine, spruce, fir, and birch. Where the tundra replaces the forests, the last trees become so stunted and dwarfed that they are only a few inches high, although they may be many years old.

Some Geographic Aspects of Animal Life

Distribution of large animals as well as of small creatures like insects is a factor in the human geographic environment. Grassy plains, when covered with vast herds of grazing animals, encouraged man first to hunt the beasts and then to tame and domesticate some animals. Asia seems to have been the original home of most of the domestic animals like the ox, sheep, horse, goat, camel, and pig. In the New World only the llama in the high plateaus and the Andes Mountains of South America was tamed and taught to carry burdens, although the alpaca, a close relative, was kept in herds as a producer of wool. The dog, found nearly everywhere among the American Indians, probably accompanied the ancestors of these people in their migrations but in part may have been derived from the taming of wolves or coyotes. Several varieties of fowl have been domesticated. Although most animal life is useful to man, some forms, especially among the insects, are harmful. Even predatory mammals (coyote, fox, and mountain lion) and birds (hawks and owls) may benefit man by killing the rodents that eat his crops. Songbirds and quail consume both weed seeds and insects and therefore deserve protection.

The distribution of native animals has resulted from many complex factors, and scientists do not agree regarding the causes and their effects. Since the subject is beyond the

purpose of this text, the discussion here will be limited to some of the human aspects related to animal life.

The different types of plant life usually are associated with their appropriate grazing or browsing animals, birds, and insects. The fauna of forests is characteristically different from that of open grasslands. During the course of their evolution, animals tend to become adapted to certain conditions; and, if the environment is changed, as happens when forests are cut or grasslands plowed, native animals suffer for lack of their accustomed food supply.

Animals that can swim and fly possess mobility, which strictly land dwellers lack. Fish show a sort of zonation based on latitude or, perhaps better, on food supply and water temperatures. Salmon, halibut, mackerel, and herring are found mostly in cool waters of the northern mid-latitudes and subpolar areas; tuna are found in the southern mid-latitudes. Sailfish, swordfish, flying fish, and marlin are restricted to tropical waters. Among sea mammals the whale is found from tropical to polar seas. Walrus, sea lions, and seals live in cold northern waters, but some of the sea·elephants and sea lions are found along tropical and subtropical coasts.

Most birds fly, and some, like the ducks and geese, migrate long distances with change in seasons; hence it is natural to find birds widely distributed. Nevertheless, many birds are adjusted to certain climatic zones and rarely leave such environments. The ptarmigan, auk, and penguin are restricted to cool wintry areas, the ostrich and emu to the tropics and subtropics. Some birds are adjusted to the natural vegetation. Among the preferred habitats are groves of hardwood trees, conifers, brushy coverts, waterways, marshland, open grassland, and deserts.

The Factor of Land Bridges and Barriers. The original distribution of the large land mammals appears to have resulted partly from natural barriers to their movement and partly from former land connections between the continents over which the creatures might travel. According to the geological record, the ancestral camel and horse originated in North America and spread southward across the isthmus to South America and westward across Bering Straits into Asia. Later the Isthmus of Panama became a strait for a time, and the Bering Isthmus became another strait, which has endured to the present. Both the camel and the horse completely died out in their original home; but the camel persisted in South America in the present-day llama, alpaca, vicuña, and guanaco, although the horse perished there also. In Asia the camel developed into both the one-humped and two-humped species, and the horse developed into several forms, one species of which became the zebra in Africa.

Similarly, the bovine species, deer, bear, dog, cat, and several other families of mammals originated in Asia and spread by land connections as opportunity offered to other lands, where some survived and some perished. The survivals nearly always became modified by their new and different environment. Among the continents, Australia has been separated from the rest of the world so long that only the most primitive animals like the marsupials, of which the kangaroo is a type, had reached that island continent before it was shut off by impassable water barriers; hence only primitive mammals are native to this island continent. Birds, of course, fly freely over bodies of water; their distribution is dependent upon food supply and habitats favorable for nesting.

Pests and Diseases. Insects and insect-borne diseases sometimes are important environmental factors. Not all insects are harmful; some, like the bee and the silkworm, have been domesticated. Others are needed for the pollination of certain plants. The fig tree, for example, could produce no fruit in California until a tiny wasp that pollinated the blossoms had been introduced. The spread of ordinary clover and the honeybee of necessity go together. Plagues of insects, like the grasshoppers on our western plains and the locust in the Mediterranean lands, sometimes occur.

Nearly every plant has certain insect parasites that eat its fruit and leaves. They burrow under the bark, gnaw the roots, or injure it in some other way. Usually other insects prey on these parasites, and climatic and other natural conditions keep down the natural rate of increase; but occasionally controls are absent or weak, and then severe damage results.

The planting of commercial crops in plantations in the tropics, where no frost is experienced to stop the natural increase in insect numbers, furnished a vast new food supply for insect pests. They are controlled by poisons, parasites that prey on the destructive insects, and the breeding of resistant species of plants. Fighting them adds to the expense and trouble of farming, but it is one of the necessary duties for successful plantation operation in the tropics. In fruit-growing sections of the United States, spraying against the codling moth, San Jose scale, and other insects, is a large item in the labor and expense of production. The cotton boll weevil (Fig. 61) Hessian fly, corn borer, the cutworm, wireworm, chinch bug, Japanese beetle, earwigs, and other crop pests must be regularly fought by United States farmers, but the total damage done crops in this country by insects amounts to many hundreds of millions of dollars per year.

Many common diseases are transmitted by insects, especially in the tropics. Some of the most deadly of these are the mosquito-borne diseases malaria and yellow fever. The tsetse fly of Africa may transmit sleeping sickness; the rat flea, bubonic plague; the human louse, typhus fever; and a certain tick, the deadly Rocky Mountain spotted fever. Even animals suffer from many diseases carried by insects. Thus the tsetse fly transmits such a deadly disease to cattle and horses that few of these creatures survive in the damp lands of central Africa. The tick-borne Texas cattle fever, until brought under control by dipping the animals in oils that killed the ticks, excluded the introduction of unaffected stock for breeding purposes. The animals died quickly, although native-born animals had acquired an immunity to the disease. Successful white penetration into tropical areas such as the Panama Canal Zone and the development of tropical plantations have depended upon the overcoming of tropical diseases, especially those transmitted by the mosquito, before the settlements could be called permanent.

Life during the summer in the tundras and taigas is made unpleasant and even dangerous to both man and beast by the swarms of mosquitoes, sand flies, deer flies, black flies, and other biting and burrowing insects. Men

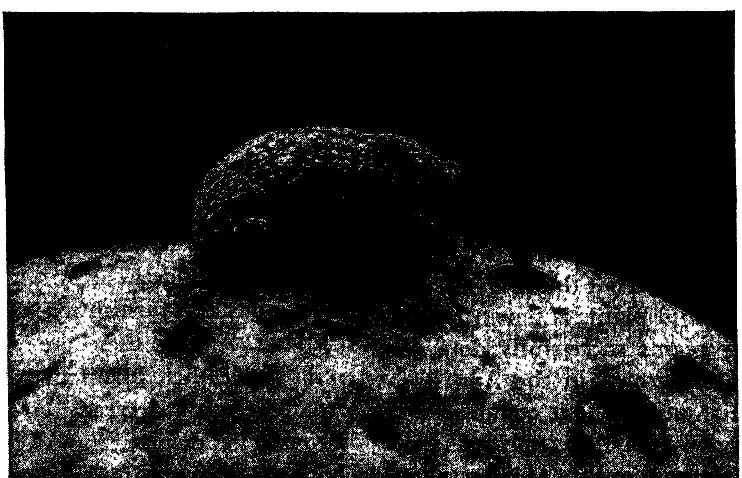

FIG. 61. Enlarged photograph of a boll weevil damaging a cotton boll. (*Used by permission of the U.S. Department of Agriculture.*)

wear head nets and gloves and keep smudges going constantly indoors and out to protect themselves. The caribou are so afflicted that they scarcely eat and often stand most of the day half submerged in water for partial protection from the pests.

The Human Factor in Relation to Native Plant and Animal Life

People in various stages of civilization and with different plants and animals available for domestication react differently to the same environment. The Indians and Europeans in the New World were exposed to the same natural factors but did not react in the same way because of differences in culture and inheritance. The relation of primitive peoples to their environment is much less complicated than that of civilized peoples who have learned to overcome natural handicaps of location. Farming and livestock in well-developed lands will be discussed in later chapters. Description of the human factor in relation to the native *flora* (plants) and *fauna* (animals) in this section of the book will refer only to primitive and barbaric peoples.

The American Indian. Each Indian group in different parts of America had a chief source of food, and its manner of life was definitely related to this food supply. The ethnologist Clark Wissler recognized eight main food areas in the New World based upon caribou, salmon, bison, Indian corn (maize), wild seeds, intensive agriculture, manioc, and the guanaco. At the extremes of the continents the Eskimo along the Arctic and the Ona and Yahgan Indians of Tierra del Fuego depended more on marine life than on land sources for food. Apparently the pre-Columbian domesticated plants and animals, except possibly the dog, were native to America and were developed by the Indians independently of the rest of the earth. That the Indians carefully tested many wild plants is shown by the more than forty plants successfully domesticated and regularly grown in the Americas. Unfortunately the animals that could be domesticated were few, the llama, alpaca, dog, and turkey comprising the list. The lower position of the Indians in their stage of civilization compared with Asiatics or Europeans was to a considerable extent the result of lack of domestic animals. Without draft animals there was no incentive to invent the plow or wheeled vehicles. The hoe and the travois served instead. Indian life in different climates of the United States will be discussed in later chapters.

Forest Hunting and Gathering. Before a forested region was occupied by civilized man, the native inhabitants lived by hunting, fishing, and gathering the wild fruits, nuts, and roots. With increased knowledge and experience, some primitive peoples learned to garden and keep a few domestic animals. Even today there are remnants of the aboriginal dwellers in the forests who keep no animals, except perhaps the dog as an aid to hunting, and who cultivate no crops. Examples include the Veddas of Ceylon, the Pygmies of the Congo Basin, and certain tribes in Borneo, New Guinea, and interior Brazil. Many products come from the forests that are in demand by civilized man. Rubber, gutta-percha, chicle, copal, dyewood, gum arabic, balsam of Peru, Brazil nuts and many drugs including cinchona bark are among the tropical products gathered from the forests for commercial sale. From the forests in mid-latitudes come cascara bark, piñon nuts, walnuts, hickory nuts, ginseng and other drugs, cork, resin, and turpentine, ferns for florists, and other interesting plant products.

Animals also furnish materials for commercial use. Among these are ivory, hides and skins for leather, furs, hair for felt, perfumes from the musk deer and civet cat, and wild animals for display. Insects furnish beeswax, honey, lac (used in shellac), wild silk, and cochineal (a dye).

Problems

1. Name climatic factors that affect the characteristics of plants.
2. Give examples of how plants are affected by weather and climate in your locality.
3. List factors, other than climate, that help to determine plant growth.
4. Where in the United States would you look for xerophytes, mesophytes, hydrophytes?
5. In a state of nature what is probably the usual climax vegetation in your locality?
6. How can plants be spread around the world? Name the barriers that restrict extension of the area occupied by a plant species.
7. Discuss the importance of land bridges and straits in affecting the kinds of animals originally resident in a continent.
8. What is the relationship, if any, between the animal life and natural vegetation?
9. Name some insects that are harmful to man and crops in your vicinity.
10. What substitutes for animal power have lessened their importance to man in this country?

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CHAPTER 7: *Tropical Climates and Their Life Relationships*

Wet Equatorial Climate

With heat and humidity like those of a hothouse, the wet equatorial climate is more favorable for plants than for human beings. Hence the rainy tropics are more noted for the riotous tangle of their luxuriant vegetation than for progressive cities, cultivated farms, or well-developed plantations. Palm-thatched huts and villages of primitive natives, rather than elaborate modern houses and industrial cities, are the rule.

The rainy equatorial climate (Fig. 62) covers that part of the earth's surface within a few degrees of the equator, save for a few exceptions to be noted later. The location of the equatorial calms determines this type of climate. In the doldrum belt rains of the thunderstorm type are a common occurrence throughout the year. The maximum rainfall comes near the times of the equinoxes. Minimum rainfall occurs near the solstice period, but no time of year is distinctly dry. In the northern summer months the equatorial calms and their associated rains shift northward about 10°, and in the southern summer (northern winter months) the belt of calms and rains shifts southward, resulting in slightly less rainfall during these two times of the year near the equator. There is little variation in annual temperature, and the average monthly temperature changes from only slightly below to slightly above 80°F. (Fig. 63). The differences in temperature between day and night are generally greater than those between the hottest and coldest months. Frosts are unknown in this belt except on the highest mountains.

With few exceptions, equatorial regions have high relative humidity, but extremely high temperatures are not a characteristic. The fact that the sun shines regularly about 12 hours per day at all times of the year prevents excessively high temperatures and helps to reduce the effects of the greater directness of the sun's tropical rays, compared with higher latitudes. Absolute maximum temperatures are much higher in the trade-wind deserts and in the so-called "temperate" latitudes in summer than during the day in rainy tropical regions. Temperatures near 90°F., when combined with the very high relative humidity of the rainy tropics, make conditions seem as unpleasant as temperatures of 110 to 120°F. combined with a low relative humidity. It is fortunate that temperatures seldom reach 100°F., since the very high relative humidity would make conditions almost insufferable for human beings. The term *sensible temperature* is used in this regard in reference to the actual feeling of a person toward the combination of heat and humidity as distinguished from the temperature recorded by the thermometer.

General atmospheric conditions in the rainy tropics resemble those of the "muggiest" days in mid-latitudes. The air seems steamy and the body with exercise keeps wet with perspiration, since moisture does not readily evaporate in the damp air. The high relative humidity and heat are very oppressive to the unacclimated person. The weather is cloudy much of the time, especially in the afternoon when most of the rains fall. These are of the convectional shower type, usually accompanied by torrents of rain and brilliant flashes of lightning. After the storm, which may last from a few minutes to less than an hour, the air usually clears, the temperature falls slightly, and living seems more endurable. Modern inventions have added greatly to the

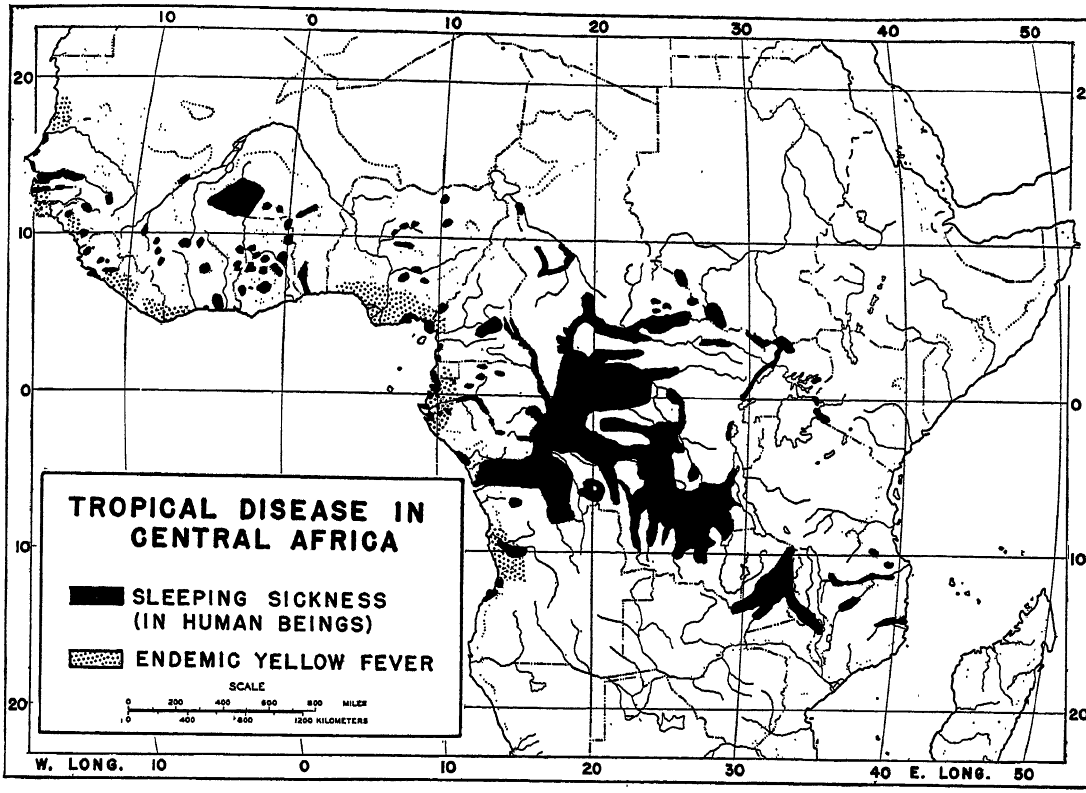

FIG. 64. Tropical disease in central Africa.

Vegetation and Animals of the Equatorial Forest. Conditions in the rainy tropics are so favorable for vegetation that a dense forest growth results. This equatorial rain forest is best developed in parts of the Congo and Amazon river basins. Brazilians call the tropical rain forest of the Amazon valley the selvas. The trees are broad-leaved evergreens and commonly form such a dense canopy that only a small amount of light filters through the leaves, making photography nearly impossible and even hindering the growth of ground plants. Many of the plants are parasites feeding upon other plants. Others are rootless epiphytes (air plants) like orchids, securing their nutriment from the air. Along the streams a dense wall of greenery exists, but back under the shade of the leafy canopy large areas of the forest have little undergrowth. In a given area there may be hundreds of species of trees, vines, and smaller plants, but the forests are notable for their lack of the solid stands of a few species of trees that are so common in the coniferous forests of higher latitudes. The climbing vines, called *lianas,* form a hanging network between the trees through which an explorer must often literally hew his way. Most of the trees run up without branches in a straight trunk for 80 or 100 feet, and then their plume of foliage joins the forest canopy.

In the treetops specialized types of arboreal life exist, rarely descending to the earth. Sloths, monkeys, climbing carnivores, and various rodents, lizards, snakes, toads, great numbers of birds, and myriads of insects inhabit the treetops. On the ground other types of life flourish. Larger animals are few and are more often the browsing type that nibbles the brush, since grass cannot grow in the shade. The heat and humidity cause a remarkable growth of vegetation (Fig. 65). Whenever

FIG. 65. Hauling mahogany logs to streams has always been one of the most difficult operations in this type of lumbering. For 300 years in tropical America cattle have provided transportation over crude trails for a maximum hauling distance of about 7 miles. (*Photograph used by permission of the Mahogany Association, Inc.*)

a giant tree falls dozens—even hundreds—of seeds germinate, and the plants compete for a place in the sun. The weaker perish, and only a few survive to reach the leafy canopy of the forest with their trunks.

Hunters of the Rain Forest. Some people imagine that life in a tropical environment is simple and that food can be plucked without much difficulty from the forest. The reverse is true. Large game animals are not so common as in the open grass country. Domestic animals are seldom kept, in part because of disease or lack of proper food, and in part because of the habits and lack of inclination of the people. Some natives, like the Pygmies in the Ituri Forest of the Congo Basin, are purely hunters and gatherers of wild fruits and other edible products. The numbers of primitive forest hunters are few, but they require a large territory to support a small population in their primitive manner of life. Their huts are temporary and little more than partial shelters against the rains.

Primitive Farmers of the Rain Forest. Other natives practice a primitive type of forest agriculture. During the least rainy season of the year, the smaller trees are slashed down and the larger trunks are girdled. Under the hot tropical sun the vegetation dries out rapidly and can be burned before the heavy rains begin. The rootstocks of bananas and certain starchy roots like cassava, yams, taro, and arrowroot, as well as vegetable seeds and other sources of food, are planted in the ashes. The ground is not plowed but is only partly stirred with crude hoes, spades, and sharpened sticks. With the rains the gardens grow rapidly. The plants are not set out in regular rows or any definite order as in more civilized communities but are mixed together almost at random. Little attempt is made to cultivate the ground except to slash down the largest weeds to give the bananas, cassava, okra, and other crops a chance to start. Where the gardens are located on sloping ground, torrential rains cause erosion of the soil. In any case, since tropical soils are often poor because of the leaching of soluble plant food from any well-drained ground by the copious rains, the life of a garden rarely exceeds 3 years. By that time, erosion, leaching of the soil, and the rapid encroachment of grass, weeds, and

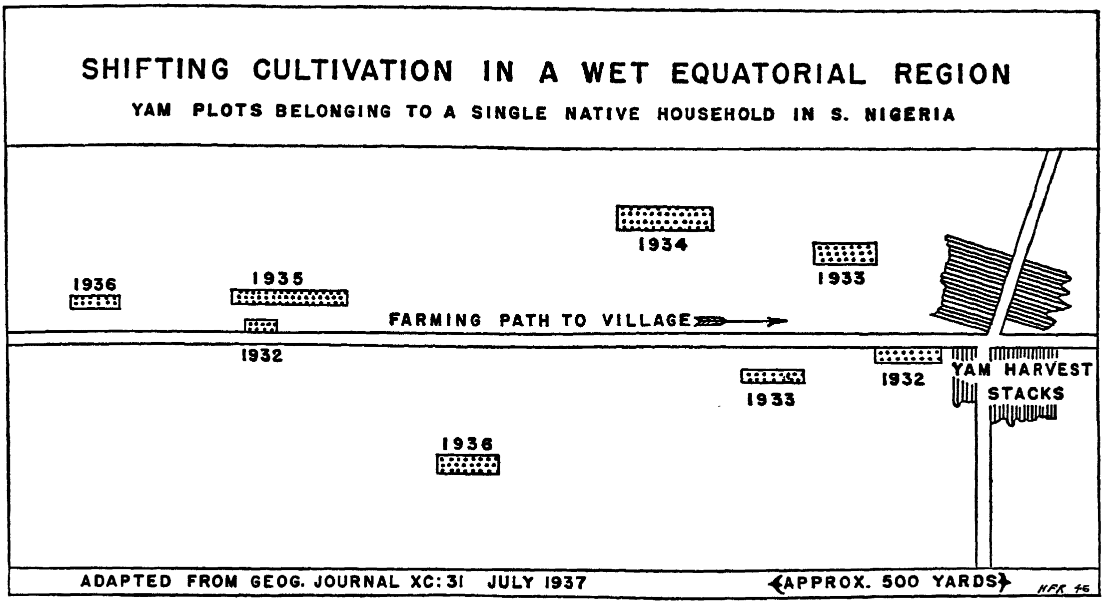

FIG. 66. Shifting cultivation in a wet equatorial region.

undergrowth cause cultivated crops to be abandoned, and a new garden is started elsewhere (Fig. 66). After some years all the land suitable for cultivation near a village has been used. Then the village may be abandoned and moved to another virgin spot in the forest where land is available for clearing and cultivating. Much of the forest in peopled regions of the rainy tropics is second growth rather than virgin forest as a result of this destructive type of farming operation.

Some of the mountain Malay tribes in the Philippines are good examples of a primitive agricultural people living in tropical highlands. The Ifugao and Igorot tribes live in the mountains of northern Luzon. There they hunt and gather wild products to supplement rice, the real source of livelihood. Because very little land in the mountains is level enough to irrigate for rice, the fields must be formed artificially by laboriously terracing whole mountainsides. During the centuries that these mountain Malays have lived in their present homes, the terraces have been extended till they constitute some of the most remarkable engineering feats accomplished by man. Terraces a few feet wide rise one above another for one, two, or three thousand feet up the sides of mountains. Mountain streams conducted on to upper terraces are permitted to run through bamboo pipes from one terrace to the next lower level. To guard the sources of water the forests are well protected, and no villager is allowed to cut timber in the forest without the permission of the elders. All this engineering, including the building of stone walls set without cement often to a height of 30 feet, was done by illiterate natives. In their tribal relationships they dwelt in peace and harmony; and, though there were no written records, they were ruled by the intricate laws developed by custom and tradition. Water buffalo and oxen were kept for domestic animals and were sometimes eaten. Pigs and poultry also supplied food along with some secured by hunting and fishing. These supplies supplemented the rice and other crops that were their chief foods. Their houses were thatched, had steep roofs to shed the rain, were erected on posts above the ground to provide air circulation beneath the floor, and were well adapted to the hot and rainy climate (Fig. 67). Some cloth was woven, pottery and baskets were made, and

FIG. 67. A dwelling among the primitive Igorot peoples of the interior of the island of Luzon in the Philippines. Houses of this type are common in tropical latitudes. The heavy thatch roof sheds rain and the supports beneath the structure keep it well above the dampness of the ground and permit circulation of air beneath the building.

even iron implements were fabricated from bars of iron over fires of charcoal.

Rainy Coasts in the Trade Winds. The rainy tropics extend farther from the equator on east coasts than in the interior of continents or along west coasts. The explanation is found in the fact that the trade winds blow from oceans that lie east of the continents, causing increased precipitation along the windward shores. Thus east Africa from Zanzibar to Natal has rain most of the year from the trades. The east coast of the large island of Madagascar enjoys heavy rainfall from the same cause, although the west coast, which lies leeward of the mountains and plateau, has a semidesert climate. The northern and eastern coasts in the West Indies, the eastern side of Middle America, part of the east coast of Australia, and other places in the world within the trade-wind zones have similar rainy coasts with resulting vegetation closely resembling the equatorial rain forests. The heaviest rainfall under the United States flag, 450 inches per year, is near the summit of the mountainous island of Kauai, one of the Hawaiian group that lies athwart the northeast trade winds.

Tropical Plantations. The statement has been made that the Amazon Valley could raise enough food to supply the entire population of the world. This would possibly be true if the whole region were under cultivation; but as a matter of fact only a tiny fraction is in farms, and the occasional clearings are negligible compared with the size of the area. For all intents and purposes the entire Amazon Valley is an undeveloped forest wilderness. Nearly the same thing is true of the warmer and more humid portions of the Congo Basin. Many tropical places actually import food from mid-latitudes to a greater extent than they export food products. The production of raw materials and foodstuffs on a commercial scale has succeeded in the tropics only by the plantation method, where natives work under the supervision of managers (Fig. 68). The capital, energy, experience, and salesmanship are provided by these outsiders. Plantations to succeed must be located along coasts or within easy reaching distance of seaports. The market for the products is in the industrial centers of the middle latitudes, and it seldom pays to transport goods from a distant interior to the coast.

FIG. 68. Raising sugar cane is Hawaii's most important industry. This view shows the laborers cutting cane by hand, but machines are now generally used to harvest cane in order to save labor. (*Photograph used by permission of the Hawaii Tourist Bureau.*)

The tropical plantations that are economically most successful are those which produce things that cannot be grown successfully in middle latitudes. Bananas, cacao, coconuts, and cane sugar are food products produced on rainy tropic lowlands.

Palm oil, coconut oil, and copra come from the tropics and are used for both food and raw materials for manufacture. Both coconuts and oil palms, however, grow wild and are raised only partly by plantation methods. Sometimes it is cheaper to produce foodstuffs by plantation methods than to gather the material from the scattered wild trees in the forest. Quinine comes from the cinchona, a native tree of the forests in eastern Peru. Today most of the world's supply comes from the plantations in the island of Java, where plenty of skilled labor is available and the product can be raised more cheaply than it can be gathered from the forest.

Many products of the rainy tropics are of distinctive flavor or are unusual in character; others are difficult to ship because of their perishability. For these reasons, and because of the expense and difficulty of producing them on plantations, they have only recently been added to the diet of mid-latitude peoples. Most tropical foodstuffs become items of luxury when shipped out of their native environment. In the last half century we have witnessed the commercial development of a long list of tropical commodities, including bananas, chocolate, Brazil nuts, pineapples, avocados, cashews, mangoes, kapok, and many others. In the near future we may become equally well acquainted with papayas, cherimoyas, and babassu nuts. To a degree, the success or failure of commercial development of this type of product depends on improvements in rapid transport and increased use of refrigeration.

Rubber. Hundreds of different trees, vines, shrubs, and herbs produce a milky latex from which rubber can be made. Several dozen plants have actually supplied rubber to the world, but only one, the *Hevea brasiliensis*, a native of Brazil, has proved adaptable to plantation methods of production. Seeds taken from Brazil were germinated in flower

pots at the Kew Botanical Gardens in London and carried to Ceylon for planting there. Today the many millions of rubber trees that grow in Ceylon, Burma, Malay Peninsula, and the East Indies have descended from these few seeds smuggled from Brazil half a century ago. In nature rubber trees are widely scattered in the forests, and the workmen must travel long distances to gather a supply of latex. Furthermore, because the wild trees did not belong to anyone, they were often killed within a few years by careless tapping methods; and rubber gatherers then had to penetrate the forest more deeply along the rivers and trails to gather a supply. This of course increased the cost of gathering wild rubber, and as a result plantations can produce rubber more cheaply than it can be gathered from the forests. Since about 1910, plantation rubber has almost completely replaced the wild article.

Tropical Islands. Tropical islands, because of their accessibility to ocean boats, are often favored for plantations. Trinidad, Cuba, Puerto Rico, and Jamaica in the West Indies; Mauritius and Réunion in the Indian Ocean; Java and Sumatra in the East Indies; Hawaii and Fiji in the Pacific, and São Tomé in the Gulf of Guinea are examples of tropical islands where the plantation method of agriculture supervised by outsiders has succeeded. Coffee and tea are grown in the tropics in highland areas from one to several thousand feet above sea level. These crops thrive better in areas that have a greater range of daily temperatures than in the humid lowlands, which have high uniform temperatures.

Wet-and-dry Tropical Climate

Transition from Rainy to Dry Tropics. In addition to the rainy tropics, tropical climates include the wet-and-dry tropical and the tropical deserts. Tropical climates with a distinctly rainy and a dry season occur in both tropical savanna and monsoon regions. Savannas (Fig. 62) are the result of the shift of the equatorial calms during the year. This zone begins about 5° from the equator, where a well-defined rainy season occurs during the period of greatest heat, followed by a dry season during the cooler months. There is little variation in temperature throughout the year, however (Fig. 69). Variation in seasonal rainfall is more apparent than variation in temperature; hence the terms summer and winter refer only to the time of year and not to the season in the savannas. In this belt, characterized by wet and dry seasons, the zone nearest the equator has a long rainy and short dry season. Farther away, the seasons are of approximately equal length; and, at the edge of the trade-wind deserts, there is a short rainy season and a long dry season.

Savannas and Tropical Steppes. Natural vegetation reflects the differences in rainfall in different parts of the wet-and-dry tropical climate. The forest is dense but of less height than in the equatorial rain forests. It is sometimes called a jungle rather than a rain forest. Where the rainfall is still adequate (from 30 to 50 inches during the season) but several months of drought must nevertheless be endured, the trees form an open stand with tall grass, brush, and other drought-resistant forms of vegetation. These open woods, mixed with grassland, are called *savannas* (Fig. 70). The llanos of the Orinoco Valley in Colombia and Venezuela, the campos of southern Brazil, and most of the Sudan region of Africa are examples of tropical savannas. As the length of the dry season increases, the trees become stunted and widely scattered and change to more drought-resistant forms like the acacia. Tall grass is replaced by short grass, and the resulting open plains and untimbered rolling hills are called *steppes*. As the desert is approached, decreasing rainfall causes elimination of all but the most drought-resistant types of plants. Sod disappears and clumps of bunch grass replace the short grass. The brush has few leaves but many roots. The leaves and

farming people and force them to furnish tribute of grain or other supplies. Lacking these, the farming settlements would be raided by the fiercer though less numerous herdsmen.

Monsoons of Southeast Asia. The monsoon areas, best developed in India, the Malay Peninsula, and south China, represent an extreme phase of the wet-and-dry tropical climate (Fig. 62). The summer monsoons blow inland from the ocean and furnish abundant rains. The winter monsoons blowing outward and downward from high and dry interior Asia cause winter drought (Fig. 72) except where this wind blows over bodies of water before rising over mountainous coasts. Then the winter monsoons may furnish rains, as in the east coast of Indo-China, Ceylon, southeast India, parts of the Philippines, and the East Indies, but these areas are small compared with those which have summer monsoon rain.

The climatic year in India is divisible into three seasons, a hot dry spring, a hot humid summer, and a moderately cool dry "winter" without frost. By the time of the spring equinox, the sun blazes down from a cloudless sky; and the heat culminates in April and May, when the vegetation has become dry, many plants have lost their leaves, and the land is so parched and dusty that human activities are reduced to a minimum. By June, the monsoon breaks, and strong winds bring in warm air masses filled with moisture from the Indian Ocean. The rains begin in the south first and may not reach northwestern India until July. The summer is hot and humid and is the period of rapid growth of crops and natural vegetation. The summer monsoon declines earliest in the north—perhaps in September in the northwest, October in Calcutta, and November in the south. The dry and relatively cool winter monsoon winds generally blow from October or November to the end of February. This is the pleasant cool season in India, though temperatures do not reach freezing, and this is the preferred time for foreigners to visit the country.

Natural vegetation in monsoon lands generally consists of jungle except in the less

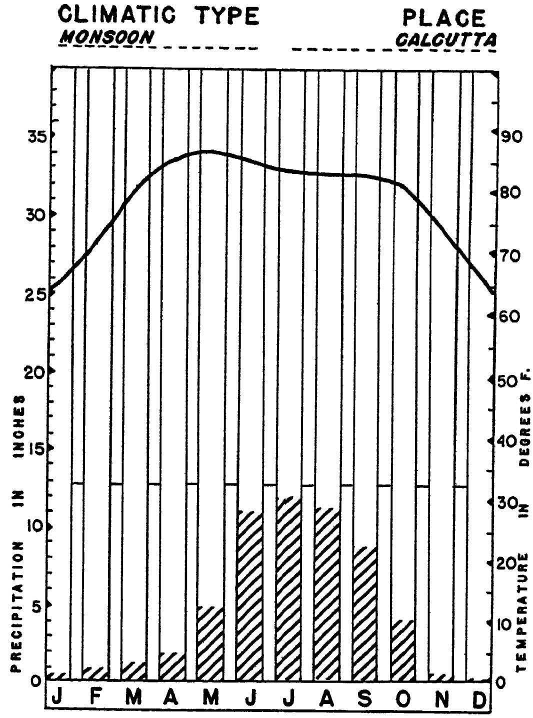

FIG. 72. Climatic graph for Calcutta, India. Rainfall and temperature conditions in a typical monsoon location. The tropical latitude is indicated by (1) a uniformly high temperature condition throughout the year and (2) a marked lack of seasonal temperature variation. Note also (3) that the total amount of rain each year is very heavy, but (4) that it occurs in an uneven distribution, with drought in December, January, and February; and heavy rains in June, July, August, and September. Note the differences in climatic condition from those of the wet equatorial climate shown in Fig. 63.

rainy sections, where it may be of a savanna, steppe, or even desert character, as in northwestern India. In the jungles man can call a destructive agent—fire—to his aid for clearing land for cultivation. In the rainy tropics the forests are so constantly damp that they are very difficult to clear by fire unless the vegetation is cut down and dried in the hot sun, but much of the jungle becomes dry enough to burn in monsoon climates at the end of the dry season. Since land is easier to clear than in the rainy tropics and the natives are better workers than those living in the hot rain forest, some of the rainier monsoon countries devote much land to plantation crops and

raise cane sugar, tea, coffee, and other commodities for export to industrial regions in the middle latitudes.

Rice and the Population of Monsoon Lands. The most important native food in the monsoon climates is rice. This grain requires a long growing season, usually about 5 months, and needs to be planted in artificial swamps (Fig. 73). A good deal of labor is needed to raise rice. Plants are started in hotbeds and transplanted spear by spear to the prepared fields, where the rice grows in the mud and shallow water under the hot sun. Rice is a hard grain and resists fungus and other diseases that would ruin wheat and similar grains planted in the tropics. Furthermore rice can be stored in spite of the heat and humidity, while corn and wheat would ferment and spoil under these conditions. Rice requires very fertile soil and an adequate amount of water in tropical or warm summer climates.

Monsoon climates having a dry season and less heat part of the year are a more favorable human habitat than the rainy tropics. Vast populations therefore exist in the rice-growing sections of Asia. Half the population on earth is found in India, China, and other countries in southeastern Asia where rice is grown under tropical and temperate monsoon conditions. Since rice requires fertile level land, the areas suitable for its cultivation are intensively used. In the Ganges delta, coastal plains of China, and the flood plains of Japan, over 1,000 people per square mile are supported wholly by agriculture. In the more tropical locations two crops of rice can be grown each year, and the yield per acre may be double that of wheat. Other areas may raise one crop of rice and another crop of vegetables, beans, or winter grain. Highlands and mountains in monsoon lands have small populations, since the people all try to crowd into the limited areas of tillable soil. Where the monsoons furnish only scattered rainfall, as in central

FIG. 73. Rice fields in the foreground, with bananas and coconut palms surrounding the farmer's home, on the island of Oahu in the Hawaiian Islands. Rice growing in Hawaii has been reduced because the hand methods used cannot compete with mechanized rice farming on the United States mainland. (*Photograph used by permission of Hawaii Visitors Bureau.*)

India and the Punjab, irrigation must be practiced or crops may be raised by dry-farming methods. Yields are smaller and the population far less than on the rainy coastal plains. Such areas are afflicted by famine when the rains fail.

Home Life in Monsoon Lands. The lives of people in monsoon lands are closely related to the climate and other geographical conditions. Houses of natives in the tropics are generally of simple construction. A roof to keep off the downpours is the important thing. The walls are loosely made and sometimes consist of movable mats so that the circulation of air is secured. Generally the house is little more than a hut that is thatched with banana and palm leaves and has a floor that often is nothing but earth. The hut is used mainly for sleeping accommodations. Cooking may be done outdoors or in the shelter of a lean-to. Only a small fire is needed, since heat is desired for cooking alone. A ditch may be dug about the hut to drain away the falling rain. Sometimes the house is placed aboveground on posts to keep things dry, especially the sleeping quarters. The floor of the elevated hut is often of split bamboo. Underneath, the pigs and chickens find refuge and pick up the scraps that fall through the open spaces.

Seasonal Changes in Monsoon Climates. During the rainy season, white people find the heat and high humidity of monsoon climates very disagreeable. Everything is affected by the dampness. The leaves of books stick together and become covered with mildew, and bindings are quickly loosened. Wet boots uncared for over a single night will be covered with fungous growth by morning. Unoiled knives and guns may be ruined by rust. The rains bring a sudden growth of vegetation. In India a short mild winter is followed in March, April, and May by heat and drought. The vegetation dries up, and the country is covered with dust; but, with the arrival of the rains in June, everything again becomes green, and the temperature drops slightly because of the cloudiness and the cooling effect from the evaporation of moisture. Summer rains make the monsoon regions a favorable place for the raising of crops, rice especially being easily stored for consumption during the dry season. The dry season also provides leisure during which the natives may devote part of their time to the advancement of knowledge, culture, and civilization.

Problems

1. What industrial advances have enabled the tropical humid regions to become sources of some of the leading commodities of world trade, whereas their commercial products were formerly limited to luxury goods?
2. How have the above conditions affected world trade routes?
3. Why is commercial production of bananas confined largely to the Caribbean area?
4. Compare the cultivation and production of jute and of cotton in India.
5. Account for the leadership of Java in the output of tropical products, and list the principal products grown there.
6. Enumerate four principal characteristics of tropical lowland climatic conditions.
7. How is the zone of equatorial calms related to the tropical lowland climate?
8. Name four parts of the earth in which tropical rain forests prevail.
9. When does rainfall normally occur in savanna regions? Why?
10. Which is best suited for occupation by the white man: tropical lowland or tropical savanna?
11. How is India's climate related to the change of season?
12. Diagram usual air movements in the vicinity of southeastern Asia in summer and in winter.
13. Group the following items according to those parts of India in which they grow best: rice, millet, cotton, jute, wheat, sugar, sheep, camels, silk.
14. Though India has an area receiving the heaviest rainfall in the world, it also has the most

extensive irrigation projects of any nation. Explain this apparent contradiction.

15. The deltas of the Indus and the Ganges are approximately in the latitude of the Tropic of Cancer. Compare their geographical conditions, and explain.
16. India raises much sugar cane and more cattle than any other country in the world. Why is India not noted for its exports of sugar and beef?
17. Why is the soil in tropical rain forests often poor?
18. What are handicaps to the development of interior Brazil?

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CHAPTER 8: *Deserts*

Deserts are of special interest to the geographer because their harsh environmental conditions so affect human activities that the relationships involved are simpler and clearer than in lands more favored by nature. The Arab and his camel, the oasis dweller, the Indians of the southwestern United States, and the nomads of The Gobi will be used to illustrate man's life in deserts.

Interpretations of the meaning of the word *desert* vary. Some geographers hold to the opinion that few true deserts occur in the United States because some vegetation is present in almost all areas. Others, including the authors of this book, look upon a desert as comprising a region that is too dry for the raising of crops without irrigation. This definition includes within the deserts several regions that provide some grazing ~~and browse~~ for livestock.

Causes of Deserts. Deserts result from lack of rainfall, but the rate of evaporation helps to determine the true boundary of a desert fully as much as the actual rainfall itself. Thus in Australia the desert may be thought to begin on the south in the vicinity of the 10-inch annual rainfall line; but on the north scanty drought-resistant spiny vegetation of the desert type extends nearly to the 20-inch rainfall line. The rainfall in northern Australia is of little benefit to vegetation, since it occurs in the warmest time of year and is followed by nearly 8 months of drought.

Deficiency of precipitation in desert regions may be due to a combination of several factors:

1. Winds that move from colder to warmer latitudes, such as the trades, thereby become warmed, and their capacity for holding moisture is increased. This drying air promptly absorbs moisture from the land beneath it, thus contributing to the formation of a desert.

2. Air moving from a continental interior region in the direction of the sea, if the distance is great, may never have had access to large amounts of moisture; it could hardly be expected to produce rain in any quantity. Furthermore, if the place of origin in the central part of the land mass is cold when the surrounding seas are warmer, the moving air will be warming as it flows outward and will tend to take on moisture by evaporation from the land surfaces, thus inducing a tendency toward a desert condition.

3. Some desert regions are deficient in precipitation because the land surface has too low an altitude to force the air to rise, thus lowering the temperature to a point at which condensation and precipitation will occur. Hence a desert condition will prevail, though the air itself may have a high relative humidity.

4. Prevailing wind directions in a few places run parallel to nearby coasts; under these circumstances the coastal belt will fail to receive any large amount of moisture from the sea winds.

5. Air that is descending vertically, as in the horse ~~latitudes, is~~ coming under compression and is warming adiabatically. Its capacity for holding moisture is thereby increasing, and there is little hope for precipitation under these conditions.

6. Some places on the earth experience prevailing winds ~~that come~~ from the sea bearing large amounts of water vapor, but the direction of the wind is at right angles to the trend of high mountain chains. The windward sides of the mountains then receive heavy rain and snow, leaving the dry air to pass over their summits, descending on the leeward slopes, and coming under compression to become an adiabatically warmed and drying mass of air. With these conditions, large amounts of rain or snow cannot be expected on the leeward

side of the mountain range, and a desert condition may result.

7. Air moving from the sea to the interior of a large continent may provide plenty of rainfall near the margins of the continent but will be drained of its moisture long before it reaches the center of the land mass, where rain normally may not be expected from such an air mass.

8. Relative temperatures of sea and land may be unfavorable for the development of rainfall. For example, onshore winds of southern Peru and northern Chile cross the relatively cold Peru Current and on reaching shore are warmed more rapidly by radiation from the heated land surface than they can be cooled as they pass eastward over the Andes. These conditions are unfavorable for producing any large amount of rainfall on the coastal lands, though the upper slopes of the mountains may receive some snow and rain.

Location of Deserts. The tropical deserts are located in the zones of the trade winds and horse latitudes, usually on the western sides of continents between the savanna lands in the equatorward direction and regions of low-latitude steppe and Mediterranean type of climate on the poleward side (Fig. 74). Eastern coasts generally enjoy abundant rainfall in these same latitudes because of the prevailing onshore winds. The largest desert on earth, familiarly called the "Old World Desert," includes the Sahara of Africa and the Arabian desert in Asia—the combination forming a broad band that extends from the Atlantic Ocean on the west across Africa and well into Asia. In the higher latitudes, however, cold winters differentiate the climate of the interior desert of Asia from the dry areas in low latitudes.

From the belt of the tropical trades on the Africa-Asia land mass, the winds blow toward the equator and outward toward the oceans. The air is warming and drying, and most available moisture is evaporated from the land surface as the wind moves along, as described in 1 above. The thirsty air causes a thirsty land. The interior of Australia, from the west slopes of the highlands bordering the eastern part of that continent as far as the western coast along the Indian Ocean, is a trade-wind desert occupying nearly half the continent. Lower California and the Kalahari Desert of southwestern Africa are other examples of deserts in the latitudes of the trades, although as a matter of fact those winds rarely flow across these areas. Trade-wind deserts are festooned around the world on the Tropics of Cancer and Capricorn, as indicated in Fig. 54, occurring on the west coasts of continents, while the east coasts in the trades are rainy because the winds there come from the ocean a large part of the time.

Poleward from the trade winds is the zone of the horse latitudes. The descending air in these high-pressure belts becomes warmed by compression, as described in 5 above, and the resulting low relative humidity and absence of warm-season rainfall help to extend the tropical deserts into latitudes beyond the realm of the trade winds. The desert of southeast California, southwest Arizona, and Sonora in northwest Mexico largely results from this cause. with barriers

Deserts may result where land lies to the leeward of prevailing winds that would ordinarily provide moisture for it, as indicated above in 6. Thus the Andes of South America enjoy abundant rains on their eastern slopes in the trade-wind zone but have desert conditions on their sheltered western slopes along the Pacific Ocean, partly because this area lies in the rain shadow of the cordillera. Farther south, in the zone of the westerlies, the rainy windward side of the Andes lies in southern Chile and the dry leeward side is on the east in Argentina. Another factor contributing to the desert condition along the coasts of northern Chile and Peru stems from the cold Peru Current, which parallels the shores of the Pacific, as shown on the map of ocean currents (Fig. 179). Cool winds from the sea, which normally would bring rain to the coast, are warmed rapidly over the land by radiation from the hot desert; this action

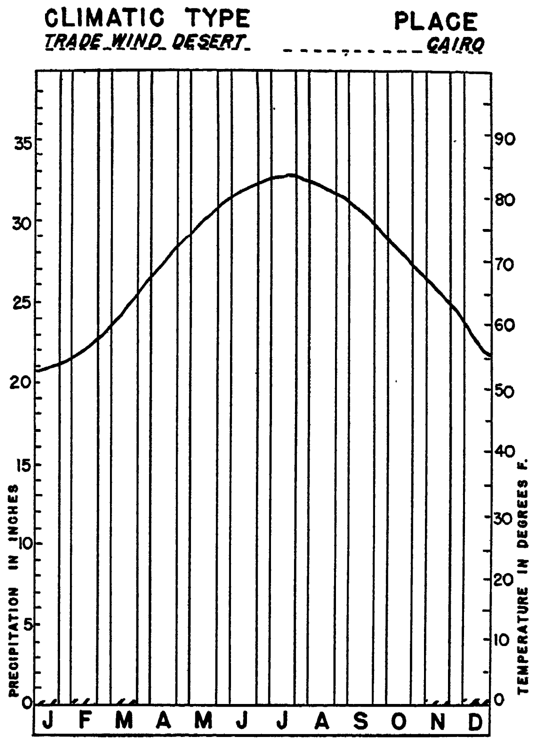

FIG. 76. Climatic graph for Cairo, Egypt. Conditions in the tropical deserts are readily distinguished by (1) high temperatures at all seasons though with some variation; and (2) noticeably deficient rainfall at all seasons.

Arabs as a *barchan,* is a common land form (Fig. 75). Elsewhere long parallel hills of sand are heaped like giant windrows in the direction of the prevailing winds, as in the Libyan Desert and parts of interior Australia. The scarcity of water in Arab lands does not require the many names for watercourses that are used in humid regions (river, stream, creek, run, bayou, slough, valley, etc.); instead the Arabs call all valleys by the term *wadi* whether they are dry or contain running water. Arabs use numerous words, however, for sand dunes of different shapes, whereas in English we use only one.

The Weather of Deserts. Characteristically the climate of deserts is one of extremes and of great variations in the always scant rainfall. Extreme daily ranges of temperature characterize the weather of deserts (Fig. 76). In the Sahara the temperature has been known to change from well below the freezing point of water at night to well above 100° in the daytime. In part this great range of temperature results from low humidity and absence of clouds. Both water vapor and clouds in the air help to keep out solar energy and also to retain heat radiation near the earth. Trade-wind deserts are in the tropics, yet freezing temperatures have been recorded over a large part of the Sahara. The low humidity of the mountains in the middle Sahara permits 10 or 15 frosty nights per year. The high variation in temperatures of deserts results in unstable

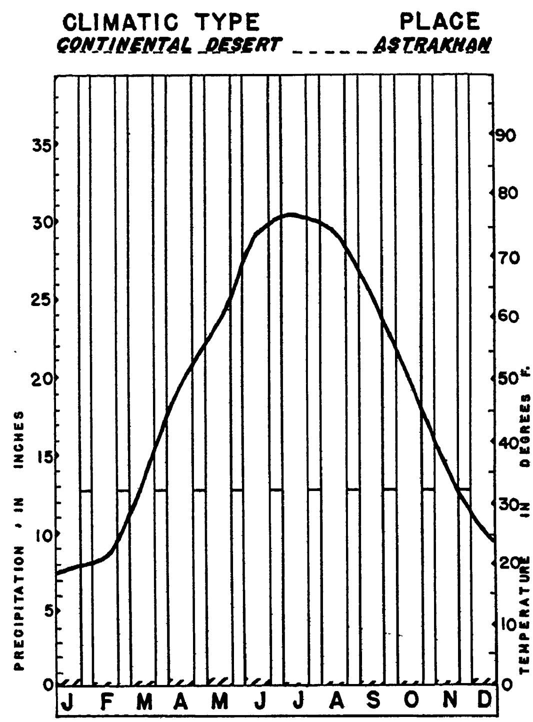

FIG. 77. Climatic graph for Astrakhan, U.S.S.R. The interior regions of the Northern Hemisphere continents normally fail to receive large amounts of rainfall from marine origins, particularly if intervening mountain ranges interfere with rainfall distribution. This location represents a climatic type in which there are (1) sharp seasonal contrasts in temperature, and (2) relatively slight but evenly distributed precipitation. Winter temperatures are severe. (Note the number of months each year that the mean monthly temperature falls below freezing.) The precipitation deficiency indicates a mid-latitude desert or steppe location.

air conditions that cause frequent sudden violent windstorms. Interior deserts in the mid-latitudes (Fig. 77) are subject to severe winters when the temperatures drop to many degrees below 0°F., although the snowfall is not large in amount. The highest temperatures ever recorded on earth have been in low-latitude deserts. At Azizia, a short distance from Tripoli near the northern coast of Africa, an absolute maximum temperature of 136.4°F. has been recorded, the highest known to have been measured by accurate instruments in the shade. One station in Death Valley, California, approaches the maximum, with an observed temperature of 134°F.

Not only is the rainfall in deserts very scanty, but it is also variable in amount and in occurrence. In fact the most reliable thing about the rainfall is its unreliability. A station over a term of years may show an average of 5 inches of rainfall per year; but some years may experience no measurable rainfall, while other years may have double or triple the annual average precipitation. Much rainfall in the tropical deserts comes from local convectional thunderstorms, which may soak a considerable portion of country heavily yet leave surfaces only a few miles distant untouched. The shifting of the wind zones and belts of calms north and south during the year causes the showers to occur in summer in the southern part of the Sahara and mostly during the winter in the northern part. Similar conditions of the rainfall regimen between the northern and southern sections of the Australian desert are also typical on that continent.

Plant and Animal Adaptation to Deserts. Special types of drought-resistant plants have adapted themselves to desert conditions. In general, perennial desert shrubs, herbs, or trees have large root systems compared with

FIG. 78. Desert vegetation in southeastern California. Most of these plants are varieties of cacti having drought-resistant spines in place of leaves. These plants are equipped to gather moisture quickly after a desert rain and to retain the water during long drought periods. A barrel cactus appears in the center foreground. (*Photograph by Frashers Photos, Pomona, California.*)

the part of the plant that appears aboveground. This suffices to gather water quickly when a local shower affords the opportunity. Furthermore they are widely spaced so that each plant secures the available water supply of a considerable area. Many plants, like the barrel cactus (Fig. 78), are especially equipped to store water in their tissues to provide for their needs during prolonged drought. Most desert plants possess devices that prevent the rapid loss of precious moisture through evaporation. Because the leaves are very small, sometimes turn their edges to the sun, sometimes may curl up to expose little surface to the sunshine, and often consist of little more than spines, the desert plants do not provide much shade. The *stomata,* or breathing organs, through which moisture escapes to the outer air also have hairs and guard cells to prevent excessive evaporation. Annual plants like grasses and flowers germinate quickly after a rain, and many mature in a few weeks on the moisture from a single shower, providing seeds that lie dormant in the soil until another shower awakens them.

Desert animals must have ~~certain attributes~~ to survive. Some ~~animals, like the prong-~~ horned antelope, the gazelle, the prairie dog, and certain other rodents, seem to make the water they need from the cellulose they eat, which contains hydrogen and oxygen, of which water is composed. Others remain dormant (estivate) during a hot dry season. The Columbian ground squirrel of the intermountain basin between the Cascades and the Rockies uses this protective device. Others remain dormant, curled up in the mud left by the evaporation of water after the temporary rainy season. The lungfish, one of which lives in the Sudan and another on a single drainage basin in Queensland, Australia, regain their activity when rains soften the mud and water is again provided for them to swim in.

The "Ship" of the Desert. Camels are ideally adapted ~~for desert life.~~ Their tough lips and tongues enable them to nibble desert vegetation. Their long legs carry them easily along the trails, while tough pads protect the soles of their feet from hot sands and sharp rocks. Extra corrugations on the walls of their stomachs permit camels by training to imbibe sufficient water in a single drink to support the animals for a week or two. The Arabian camel (Fig. 79) is fitted for life in hot deserts, while in central Asia the Bactrian species has long woolly hair and can withstand the severe cold of winters in the interior desert there. As

FIG. 79. Dromedary camel, characteristic of the heart of the Sahara. The large splayed feet make it possible for this animal to travel easily over deep sand.

a rule camels are used for bearing burdens while horses are reserved for long desert journeys where speed is essential. Dromedary camels have made 75 miles or more per day while the ordinary baggage camels seldom average more than 15 to 20 miles per day.

Occupance of Deserts

Land use by man in deserts consists of (1) intensive farming on small areas or oases, by irrigation with the available water supply, and (2) widespread use of the scanty grazing for the nomadic herding of domestic animals. In the Old World Desert the inhabitants have camels, goats, sheep, and comparatively few horses, which are treated almost like household pets. Goats and sheep are generally preferred over cattle by desert nomads because they can get along on meager forage.

Desert Nomads. The desert nomads must travel whenever and wherever conditions require, to secure grass and water for their livestock. A nomad's home and its furnishings must be easily portable. The nomads live in tents and use rugs, blankets, and shawls for bedding, floor coverings, and decorations inside the tent. Cooking utensils are few and must be made of metal because china and pottery would break easily under conditions of desert travel. Clothing must protect against the heat of day and the cold of night (Fig. 80). Among the Arabs the burnoose, a flowing robe, answers the requirements and is the accepted garment for the nomad in the hot desert. The people of The Gobi and other interior deserts of central Asia where the winters are very cold dress in woolen and padded garments and sleep in the hemispherical yurt—a portable house with slabs of padded wool laid over a framework of poles (Fig. 81). Leather or skin bags are used to carry water and other liquids. Cooking may be done with a fire made of camel dung because wood is rarely obtainable. Because of lack of fodder, large numbers of animals cannot be kept for each family. Meat is eaten but is not available throughout the entire year; and thus for long periods nomads may live largely on the milk from their goats, camels, or other animals, supplemented in the Sahara and Arabia with dried dates from the oases and a little barley meal or other grain secured by trading. Occasionally wild game will be secured to vary the monotonous diet.

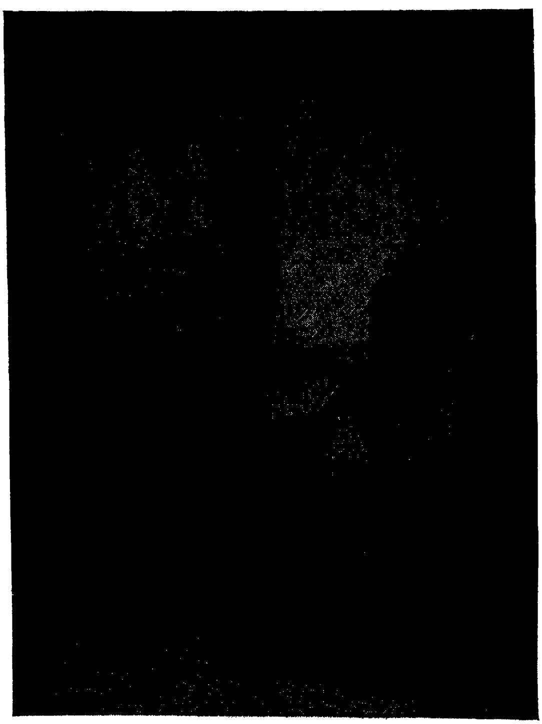

FIG. 80. Bedouins of the Old World Desert regions. Note the use of woolen garments that protect the body against sandstorms and shelter it from the effects of low-latitude temperatures.

In their own environment nomads develop characteristics suited to their life. They must have sound physique. Leanness and muscular development, combined with bravery, hardiness, and ability to live cheerfully on a scanty monotonous diet, are characteristics of these people. They are suspicious of strangers, since wanderers may try to rob or destroy part of the herds; but, once a visitor has earned their

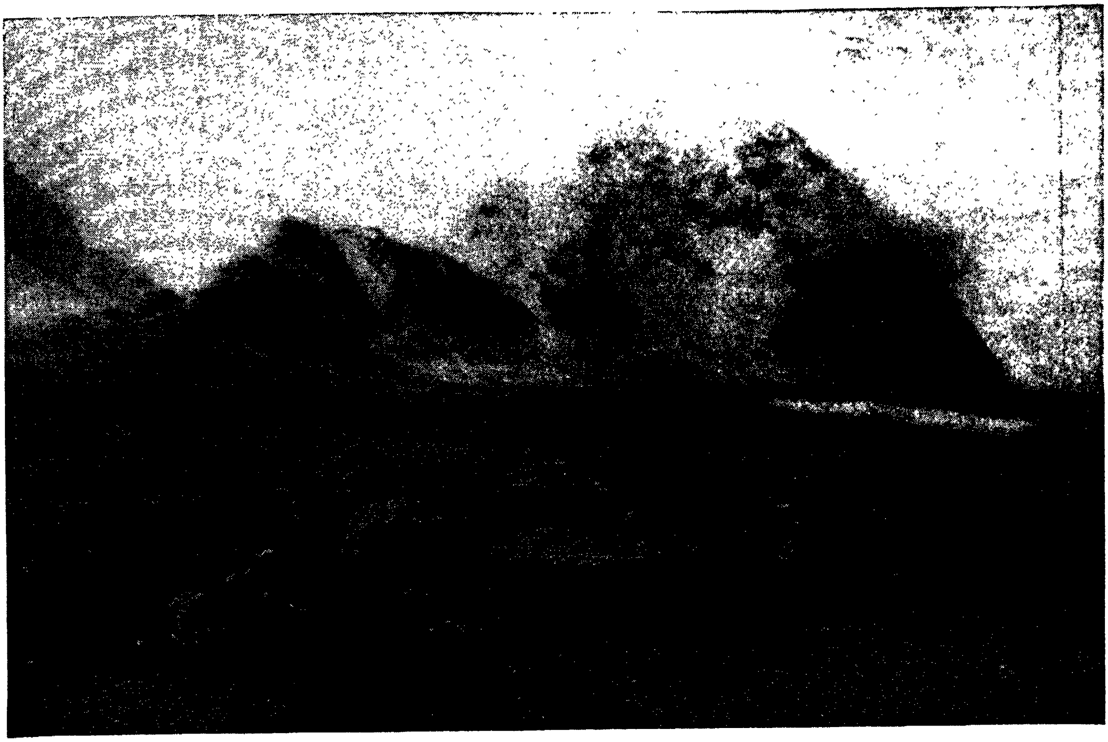

FIG. 81. Camp of nomadic Kirghiz tribesmen in the interior desert lands of Eurasia. The shelters, called yurts, are readily transported when it seems advisable for the community to move. (*Photograph courtesy of the American Museum of Natural History, New York.*)

confidence, they are generally very hospitable. Travelers as a matter of course are entertained by tribesmen, since towns and hotels for the accommodation of visitors do not exist. Occasional visitors provide welcome information about feed and water or tales from the outside world. Desert nomads are notable hunters and warriors. They must protect their herds from predatory animals, and the same weapons and ability used in fighting wild beasts may be used against human beings.

The Desert Oases. Oases are located in deserts where water is available. The water may come from rivers that originate in rainy regions and have sufficient volume to maintain a flow across the desert. The Nile is a striking example of this type of oasis. More often the water supply comes from underground sources, possibly hundreds of miles away. For example, much of western Queensland is underlain by a vast artesian basin where "bores," as artesian wells are there called, supply water to the cattle and sheep. The water in much of the Great Artesian Basin is slightly salty and therefore unsuited for irrigation. Few cultivated crops have been supplied from this source. Elsewhere groundwater supplies can be reached by wells of reasonable depth, for the irrigation of dates, grain, and other crops. The sandy beds of the valleys that wander into the desert from a mountain range have surface flow only at long intervals, but their regular subsurface supply can be reached through shallow wells. Numerous oases in southern Morocco and Algeria have developed from the supply of irrigation water in the sandy beds of the valleys, or wadis. Springs at the bases of mountains or toward the center of desert basins are other sources of water supply used for the development of oases. The soil of deserts is often very fertile because the soluble ferti-

lizers have not been dissolved and removed by water. Hence, when irrigated, desert land may be very productive.

The land that can be irrigated in any desert is small in comparison with the extent of the desert itself. In the dry western parts of the United States, if all the rainfall could be used for irrigation, only a small fraction of the land could ever be farmed. The same condition of affairs holds true for Iran, Turkestan, and other Asiatic deserts. It is obvious that all the available supply of water in deserts can never be enough to irrigate them, since much of the water runs off in sudden floods following the cloudbursts characteristic of desert rainfall, and rain water also evaporates or sinks away where man cannot find it.

The available oases generally support a great density of population per unit of land area, for water is life in the desert. Thus Egypt has over 15 million people living on only 12,000 square miles of tilled land, with the number of actual farmers in excess of 1,000 persons per square mile. The remainder of Egypt covers 345,000 square miles but contains only 40,000 nomads eking out a precarious nonagricultural existence. The real land of Egypt is the narrow valley of the Nile River and the delta of that stream, for without the river the great civilization of this important country could never have existed. Iraq, Iran, and Turkestan in Asia show similar concentration of population on the irrigated lands, with comparatively few nomads and stockmen who reside in villages thinly scattered over vast territories.

The Date Palm. The date palm is ideally adapted to tropical desert cultivation (Fig. 82). To thrive, it is said that the date palm should have its roots in the perennial springs and its crown in the blazing sun. In actual practice, dates can be successfully raised with a thorough soaking of the ground only once or twice a year. Many varieties of dates are grown, only a few of which are dried for export trade. The date palm furnishes food for both man and beast. The seeds are ground and fed to camels. The fiber makes rope, and the leaves are used for baskets and matting. The large stems and roots serve for fuel. The trunk of the tree is the only available lumber for houses and furniture. A good date palm will produce five or ten bunches of dates per year weighing perhaps 100 pounds each. In the entire Sahara, which is much larger than the United States, it has been estimated that 12 million date palms are growing. Including Egyptian irrigated land, however, the entire area of the oases in the Sahara is less than the size of the state of Oregon.

FIG. 82. Date picking in the Coachella Valley, California. The dates do not ripen at the same time on any single bunch, and picking therefore is highly selective. Each bunch is protected from moisture and dirt by a paper cover. (*Photograph by Frashers Photos, Pomona, California.*)

The Inhabitants of Oases. The life of an oasis dweller offers much contrast to that of a desert nomad. Oasis inhabitants live in houses of stone, brick, or mud. Sometimes a wall surrounds the village for protection, and the

houses may be built several stories high, with numerous families living in a single apartment house. Towns containing buildings towering eight or ten stories high are common in the Hadramaut of southern Arabia. An oasis village has shade and appears delightful to the eye from a distance, but it is not the earthly paradise for permanent residence that is oftentimes imagined. Water is too precious to waste on lawns and flowers; all must be used to irrigate the date palms, grains, and vegetables. Streets are dusty, and green lawns are notable for their absence. Flies and myriads of other insects thrive in oases.

Generally inhabitants of oases are less bold and vigorous than the desert nomads. They are tillers of the soil rather than herders, hunters, or warriors, and in Egypt they are known as the *fellahin*. Oftentimes the oasis dwellers pay tribute to the nomads, in return for which the latter will protect the village from others. A few trades and crafts, such as rug weaving and metalworking, are carried on in the oases. The community is generally of the self-sufficient type and can get along without a great deal of intercourse with the outside world.

Religion. Desert dwellers, perhaps because of the great hardships they endure and the feeling that there must be a pleasant "hereafter" to compensate for the difficulties of this life, are often imbued with a very strong religious feeling. Mohammedanism, Judaism, and Christianity all originated in the deserts or near deserts; and their literature is replete with parables, stories, and attitudes that show the conditions under which nomadic herdsmen live. In Arabia and northern Africa, the dominant thing in the sky line of a desert town is the tapering tower of the mosque; and, whatever the inner character of a man may be, there everyone obeys at least the outward forms of his Moslem religion.

Stock Ranches in Deserts. The grazing of livestock is one of the primary industries that can survive in the harsh environment of desert lands. Sometimes men keep sheep and cattle on enormous stock ranches, as large as an American county of hundreds of square miles or scores of thousands of acres. Such ranches exist in the western United States, Argentina, and central Australia. Frequently they tend to deteriorate in time, and only those ranches survive which have enough irrigated land to raise hay to carry animals through the drought periods. Grazing areas that lack hay land may be abandoned entirely, or the people who operate them may tend to deteriorate because they must be contented with a low standard of existence.

Pueblo Indians. In the arid American Southwest the deserts have colder winters than the tropical trade-wind deserts, and life relationships here have some similarities to those of Arab lands, as well as differences. In the American desert, two types of Indians lived side by side, the Pueblo Indians and the nomads. The Pueblo Indians once occupied the entire plateau country, but before the arrival of the white man their numbers and importance declined. Many ruined cliff dwellings and abandoned Pueblo villages show the large area they formerly occupied. The existing village sites are located on the tops of nearly inaccessible buttes or mesas for protection (Fig. 83). The villages consist of one or more community houses generally of stone and adobe brick with wood used only for roofs, ladders, door frames or other openings, and the doors themselves. Each family has its own rooms, and structures are sometimes four or five stories high.

Pueblo Indians support themselves almost entirely by agriculture. Corn, beans, squash, and other gourds are the principal crops. They formerly made superior pottery and other utensils. Little game was hunted, since the Indians lived in permanent locations, and animals within convenient hunting distance were few. Water is a problem. Rains furnish part of the supply, but most of the water is laboriously carried in jars by the women from distant springs up the steep and rocky trails. Water is used mainly for cooking and drinking; little can be wasted for washing and none

FIG. 83. The Pueblo Indians built their community houses of stone and adobe on isolated hills for protection against more warlike tribes. These Indians raised corn, beans, squash, and other crops in the sandy soils of nearby bottom lands where flood irrigation supplemented the light variable rains of the Colorado Plateau region. (*Photograph by Frashers Photos, Pomona, California.*)

used for flowers or grass to beautify the village.

Some Indians practice irrigation on a small scale from springs or tiny streams, but most of their crops are raised by flood irrigation. Corn is planted in the sandy alluvial fan at the mouth of a dry wash or canyon coming down from the mountains or plateaus. The rainy season in Arizona and western New Mexico comes in July and August, mostly in the form of heavy local thunderstorms. As a rule, sufficient water is retained from the preceding winter in the sandy soil to germinate the planted kernels of corn, but not enough water exists to mature the crop. The Indians depend upon the summer rains to furnish the needed supply of food. Their religion and ceremonies, including the so-called "snake dance," were efforts to propitiate the god of rain so that crops would be good and food plentiful. The Pueblo Indians have large storehouses and often have 2 or more years' food supply in storage. The tribe is therefore not completely dependent upon the uncertain rains of any one particular year but stores up part of the surplus in favorable years for use during unfavorable times. Today some of these Indians make pottery or silver-and-turquoise jewelry for sale to tourists.

Indian Nomads of the American Southwest. The nomad Indians of the Southwest hunted game, the antelope on the plains, and the deer, mountain sheep, and bear in the mountains. They gathered cactus fruits, used the mesquite beans, and collected piñon nuts from the mountains along with some other fruits and roots. In addition, some of the desert Indians like the Papagos planted small patches of corn hoping that rain would mature a crop with flood irrigation. The nomads spent the summer in the mountains and the winter in the lower desert plains and valleys. They lived in desert tents or shelters of brush or earth called *wickiups* and *hogans*. Even

today on their reservations, Indians like the Papagos live little differently from the way they did before the arrival of white men, since the latter have not cared to occupy the desert except at mines and irrigation sites.

The Navajos were originally nomadic Indians, but incoming white men brought them domestic animals, cattle, sheep, and goats. They also taught the Indians the arts of metalworking and weaving (Fig. 84). Now these Indians weave blankets on homemade looms and make silver ornaments for their own use and for sale to tourists. Many of the Navajos still lead a seminomadic existence with their herds of sheep and other animals. Their new life is far more favorable than their former nomadic hunting existence, as is shown by the threefold increase in the population of the Navajos in about two generations.

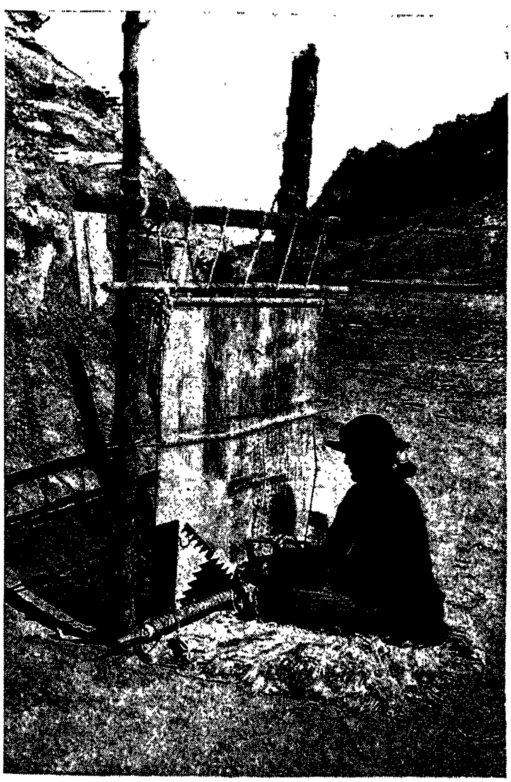

FIG. 84. A Navajo woman at work before her loom, weaving a rug from wool obtained from the sheep which graze the Colorado Plateau region. This industry developed after the arrival of Europeans. (*Photograph by Frashers Photos, Pomona, California.*)

The southwestern Indian has shown remarkable ability in the utilization of the few plants available in his environment. Among the desert plants is the mesquite, which can send its roots 30 to 40 feet into the ground to tap underground water supplies. In the spring the mesquite is covered with sweet blossoms, a favorite pasture for bees. In the fall the tree provides a crop of nutritious "beans," food for both man and animals. The fruit of the saguaro, prickly pear, and other cacti is eaten raw, dried, and cooked. A drink is prepared from the juice of some cactus plants. Numerous small plants supply greens for cooking. The yuccas and agaves furnish fruit that is occasionally eaten; but they are more important for their long tough leaf fibers, woven by the Indians into textiles for clothing, sandals, cords and rope, head nets for carrying burdens, and lariats. The roots of the yuccas supply a natural soap to the Indians. Originally all the necessities of the Indians in the arid Southwest came from the apparently scanty resources of the desert.

Occupance of Asiatic Interior Regions. Outside the developed oases in the deserts of central Asia, part of the native peoples are nomadic and some dwell in semipermanent villages. The village houses generally are poor affairs, built of brick or clay or sometimes of stone because of scarcity of timber and poverty of the people. The nomads, on the other hand, generally use the movable yurt because the low winter temperatures of central Asia demand a warmer house. In contrast, the Arab of lower latitude deserts requires little more than a sunshade for his tent. The yurt has a roof opening through which smoke from the fire of wood or dried animal dung escapes. Meat is roasted or boiled, and this diet is supplemented with milk, often used in sour or fermented form, and grain secured by trading with farmers at the oases. Some wild game is also available. To resist the winter's cold and the sharp drop of temperature at night, even in summer,

FIG. 85. Sarikol tribesmen in the Pamir district of Chinese Turkestan. Note the warm padded clothing and heavy felted hats which are needed for comfort in this continental environment. (*Photograph courtesy of the American Museum of Natural History, New York.*)

warm clothing must be worn to obtain protection from the penetrating winds (Fig. 85). Heavy woolen rugs, sometimes woven and frequently made of felt, are in common use to make the interior of the yurt comfortable.

Some governments, particularly in the Soviet Union, are attempting to induce the nomads to abandon their wandering mode of life and settle permanently in villages or settlements. Irrigated areas are being extended, and a few railroads have been built to reach the edge of these interior desert regions. Trucks are beginning to penetrate still further and have begun to replace the Bactrian camel and other animals used for caravans. The heart of Asia's interior desert area is, however, still relatively unaffected by modern civilization.

In the lives of these people, religion is important and many of their activities are carried on in connection with their religious beliefs and customs. The cities of Ulan Bator (Urga) in Mongolia and Lhasa in Tibet are centers of religious rites; here are the sacred residences of grand lamas who claim both spiritual and temporal power. The natives who dwell within this self-contained desert land are hardy, patient, bold, and averse to change; but they are very hospitable once their confidence has been gained. These characteristics they have in common with other peoples living in remote places under primitive conditions.

Present-day Desert Life. The examples of desert life previously described represent conditions among primitive peoples and in most deserts of the tropical and subtropical regions. In a few places, however, modern inventions and improvements have made possible the occupation of oases by large numbers of people. Much of the life in Cairo, for example, depends upon modern transportation facilities and newly devised systems of water storage and distribution. The construction of large dams at Aswan and Sennar provides irrigation for thousands of acres of land in Egypt that would otherwise be unproductive. Railroads and air lines make accessible to the outside world remote interior parts of the Sahara that have never before been used by man. The last few years have witnessed the exploration and mapping of hitherto unknown parts of the Sahara, Arabia, and central Australia. In these changes, the

motorcar has played an important part in one form or other; caterpillar tractors, powerful engines, and large soft tires are used for traversing sandy stretches. Railroad lines have penetrated for some distance into the western Sahara, and above all the airplane has shortened the time of crossing deserts, thereby removing former threats to the safety of travelers.

Other inventions have made the lives of desert peoples more comfortable. Mechanical refrigeration in its various applications makes possible the preservation of food, the palatability of water, and the cooling of houses. Electricity in the form of the electric fan and for cooking purposes has cut down on unnecessary and unpleasant heat. The radio has brought communication to the lonely desert wastes, removing the solitude and isolation.

The introduction of water by dams and aqueducts has made possible the commercial development of agriculture in some parts of the New World deserts. Water from the Colorado River gives life to date plantations that provide sharp contrast to those of the Old World, for the dates are planted and grown scientifically. They must be fertilized by hand in the old way, but American dates are provided with just enough water for their needs. They are carefully protected against dampness and dirt while they ripen and are picked by hand and attractively packed for sale under sanitary conditions. Other desert-grown products, such as grapefruit, melons, tomatoes, papayas, peppers, and carrots, regularly find their way to American markets packed in "dry ice" or in refrigerator cars, shipped by rapid transport so they will reach the consumer in prime condition and bring high out-of-season prices. There is little indeed about life in parts of the American deserts that resembles the unfavorable living conditions of the Old World deserts.

Mining may bring a temporary peopling; but ore bodies are worked out in a compara-

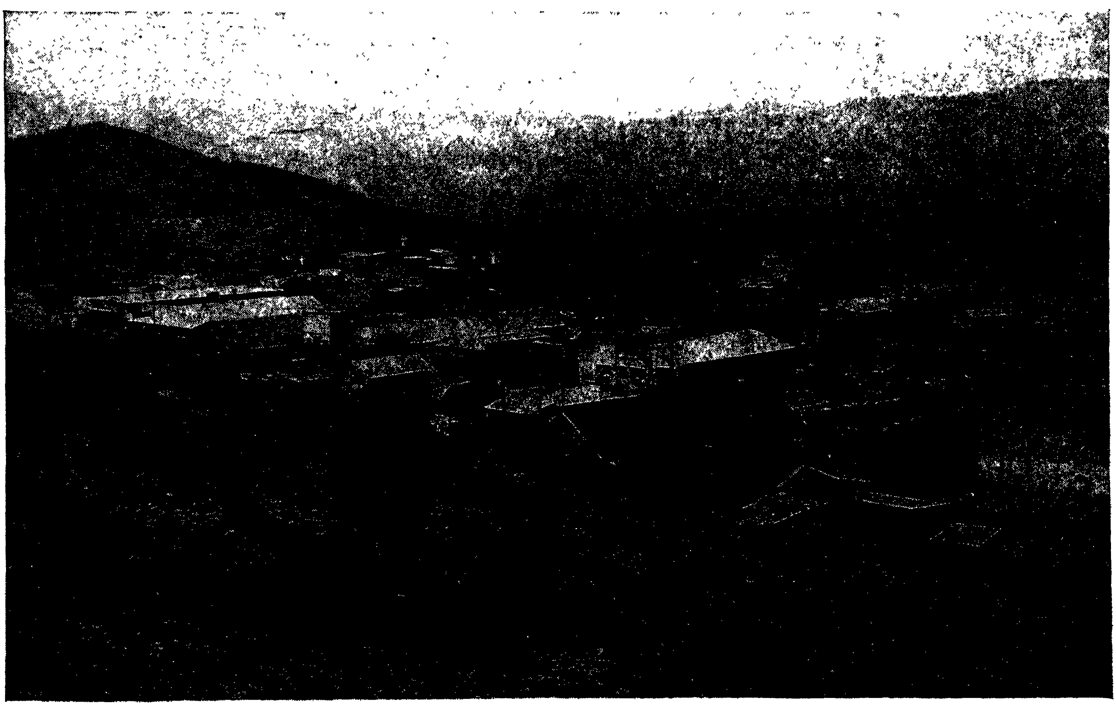

FIG. 86. Randsburg, California, a partly abandoned mining town in the heart of the Mojave desert region. (Note the roofless stone walls of the structure at the right.) The hill slopes are covered with scant desert plant growth.

tively short time, and then the improvements and settlements are abandoned and nearly forgotten (Fig. 86). A type of mining that results from desert conditions is that of nitrates, borax, potash, and other salts resulting from evaporation.

Problems

1. In a statement no longer than 10 lines, explain: "Deserts are coincident with great gaps in the world's population map." How does your population map bear this out?
2. The Nile delta and the delta of the Tigris-Euphrates (Shatt al Arab) are located in latitude 30°N. Their conditions of climate, vegetation, and soil are not essentially different; yet, from the standpoint of their usefulness to human beings, they vary widely. Why?
3. What is the relationship between the zones of extratropical calms (horse latitudes) and the presence of tropical desert regions?
4. Compare as fully as possible the conditions that prevail in the Imperial Valley oasis with those of the Nile oasis. Account for the differences.
5. Why are the soils of tropical deserts usually very fertile, provided that enough water is available from sources outside the desert with which they may be farmed?
6. Investigate the commercial production of (*a*) guano, (*b*) nitrate of soda, and (*c*) borax in the low-latitude desert regions of the world.
7. Name and locate the five large low-latitude desert regions of the world. Which is of greatest extent?
8. How does life in the hot deserts of the world bear out this statement: "Within a region which has a broad similarity in climate, there is necessarily a tendency toward similarity in economic life."
9. If the Andes Mountains were not present, desert conditions would still prevail in northern Chile and western Peru. What effect, however, has this mountain range on the distribution of rainfall in western South America?
10. Why is the economic development of the deserts in central Asia greatly retarded?
11. Can you determine the approximate direction of the prevailing winds in Fig. 75 as indicated by the sand-dune pattern?

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CHAPTER 9: *The Middle Latitudes*

Though it has not always been so, the people who live in mid-latitudes today lead the world in the advances of civilization, particularly in the development of manufacturing, rapid transportation and communication, the application of machinery to agriculture, trade with inhabitants of other climatic regions, and in general the progress that is implied in the expression "Western Civilization." In these latitudes, climatic conditions normally favor advance in civilization, although some areas, as described in the preceding chapter, are too dry for the best interests of man. Our own country lies in the mid-latitudes, and within its borders it contains most of the climatic types that occur in these latitudes.

Climates of the Mid-latitudes. Cyclonic storms, characteristic of the zone of the westerly winds dominating the region, are the most important factor affecting climates of the middle latitudes. These storms follow paths in lower latitudes during the winter of the Northern Hemisphere; even the subtropical Mediterranean region then receives moderate rainfall associated with cyclonic disturbances. Other important climatic factors are (1) the location of the semipermanent areas of high and low pressure, especially where these pressure areas control air movements from land to sea or from sea to land; (2) the distance of continental interior regions from the ocean, which largely determines ranges of temperature; and (3) high mountains and plateaus, especially where these highlands lie broadside to prevailing winds. The Sierra Nevada-Cascade and southern Andes Mountain barriers, for example, cause heavy rainfall to windward and deserts or semiaridity to leeward of the mountains.

The middle-latitude climates are characterized by four seasons and relatively large ranges of temperature compared with the tropics, and they may be divided into the subtropics equatorward and a colder zone poleward. The subtropics include the Mediterranean dry-summer climate of west coasts and the humid subtropical climate of east coasts, usually with semiarid steppes or deserts occupying the interior between the two diverse coastal types. The cooler mid-latitude climates show decreased rainfall from the west coast inland, accompanied by increased range in temperature between winter and summer. Toward the east coasts, rainfall increases again; but the temperature range remains continentally great, since the westerly winds predominate from the interior and winds do not blow inland from the eastern oceans frequently enough to moderate the temperature.

The Mediterranean Climatic Regions

Characteristics and Causes of the Climate. Following the general nomenclature of climates based on rainfall and temperature, the transition area between the trade winds and the prevailing westerlies might be described as a semiarid subtropical region with dry summers and rainy winters. Since climate of this nature is characteristic of most of the shores of the Mediterranean Sea, it is usually called the *Mediterranean* type of climate (Fig. 87). It occurs in southwestern California along the coast, in central Chile, southern and southwestern Australia, and in the extreme southern tip of Africa near Capetown. Typically this climate has hot dry summers with most of the rain falling in winter, decreasing equatorward toward the trade-wind desert, and increasing poleward as the climate grades into that of the rainy west coasts of mid-latitudes. The rainy season in the Southern Hemisphere

FIG. 89. Chaparral on southward-facing mountains in Angeles National Forest, southern California. The thicket of chaparral in the lower left corner indicates the dense growth of chaparral plants. Bull pine tops the distant mountain ridge, and the line separating the chaparral cover and the forest cover is clearly marked. (*Photograph courtesy of the U.S. Forest Service, Department of Agriculture.*)

brush. Different plant species form the brush in the different parts of the world having Mediterranean climate, but the general appearance of the hilly landscapes is similar no matter what the plant species may be. In California the brush is called *chaparral* (Fig. 89) or *chamisal,* and its prominent species include the toyon, sage, manzanita, and yucca. On Mediterranean shores the brushland is known as *maqui* or *macchie,* while in central Chile it is called *matorral.* In Australia, scrub types of eucalyptus are called the *mallee.*

Mediterranean Livestock. In spite of summer drought, abundant grass during the winter and other pasturage available in Mediterranean regions make these areas attractive for grazing. The merino breed of sheep, producing the highest grade of wool in the world, was developed in Mediterranean Spain. Although good "rustlers" like sheep and goats are more common, numerous cattle graze on the lush feed of subirrigated valleys and on the hills where more browse than grass is available. Where brush predominates, the goat can thrive, and in such localities the animal serves as the poor man's cow. Since donkeys and mules require less grain, good grass, or hay than horses, they are generally preferred along with the ox for draft purposes. Pigs graze on the acorns and other mast of the forest, although they are not so abundant as other animals. Livestock may suffer from lack of fodder if the usual time of arrival of the winter rains happens to be delayed; and regions of Mediterranean climate in which droughts frequently occur can support little agriculture, livestock, or population.

Mediterranean Agriculture. Agriculture in Mediterranean regions is favored by lack of frost and the resulting long growing season but is limited by summer drought and available irrigation water. Grains are planted with the beginning of the rains in November or December in the Northern Hemisphere and mature in late spring before the hot summer weather can burn the grain and cause the kernels to shrink. Winter wheat, barley, and millet are common grains. Various vegetables and small fruits can also be raised as winter crops. During the summer some hardy fruits like the chestnut, walnut, and olive can mature without irrigation (Fig. 90). These tree crops are often planted on hilly ground with the trees widely spaced, and they grow on the normal rainfall around the Mediterranean Sea. In regions where the rainfall is about 20 inches annually, even grapes can be raised without irrigation.

Most fruits suitable for the Mediterranean climate produce best with irrigation. These include oranges, lemons, grapefruit, and other citrus fruits; the vine, the fig, peach, apricot, and various other soft-fleshed deciduous fruits; and the olive. Fine-quality fruits can be produced because of the abundant sunshine and irrigation water together with the natural fertility of the soils. Some of the fruit is canned, dried, or preserved in other ways. Sunny weather in the harvesting season favors the drying of raisins, currants, prunes, peaches, apricots, and figs, although much fruit is dried artificially. Some is shipped fresh to distant markets, since modern refrigeration makes such shipments possible. Typical exports of Mediterranean regions are wine, olive oil, and fresh or preserved fruits. Very dense populations can be supported on irrigated land, as many as several hundred people per square mile making a living from farming

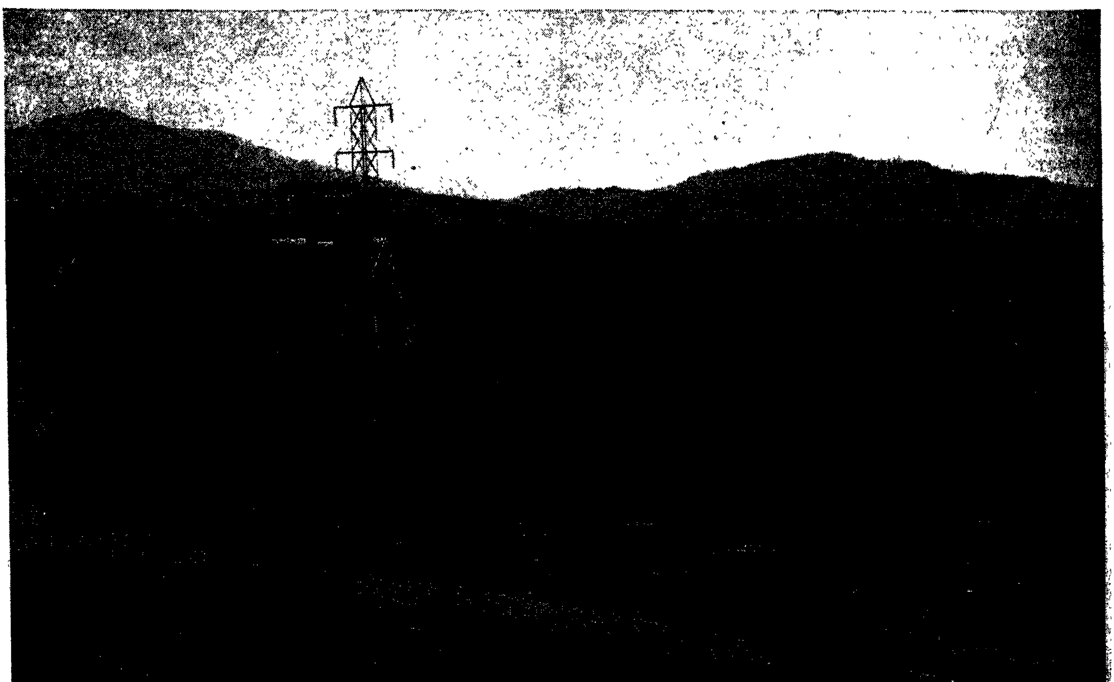

FIG. 90. Grove of olive trees in the San Fernando Valley, California. These trees must be irrigated to obtain a satisfactory crop. Electric transmission lines cross the groves, bringing hydroelectric power to the houses and factories of Los Angeles and other southern California cities. (*Photograph courtesy of the Los Angeles County Chamber of Commerce.*)

alone. Without irrigation the farms must be larger, and in some of the grazing sections the ranches may be very large indeed.

People in the Mediterranean Climate. As a rule, Mediterranean regions cannot support so great a density of population as the monsoon regions of similar latitudes, since in the latter the people are mainly rice eaters and rice is more productive per acre than wheat or barley. In general, Mediterranean regions are healthful because great extremes of temperature and rainfall are lacking but there is sufficient variation in weather conditions to be stimulating to man. The small variation in temperature is reflected in the types of houses characteristic of Mediterranean lands. The short supply of timber encourages the use of stone or brick in building construction and the extensive use of tiled roofs and floors. Roofs tend to be flat or gently sloping, since snow is almost unknown in these latitudes.

Regions having Mediterranean climate attract the residents of colder stormier lands, and California as well as the countries adjoining the Mediterranean Sea have capitalized on this fact to attract tourists. These visitors come especially in the winter season to enjoy the sunshine, mild days, and verdure of the subtropics. The motion-picture industry originally moved to southern California from New York and Chicago because outdoor scenes could be photographed practically every day in the year. After its early growth near Los Angeles, this industry tends to remain concentrated there, even though indoor photography is now a common practice.

Erosion in the Mediterranean Region. For centuries erosion has been a problem in the Mediterranean region because of the relief features, climate, and human factors. The Mediterranean Sea is nearly surrounded by hills and mountains. Areas of level land are limited, and the construction of terraces is resorted to in many areas to retain soil for cultivation and to make irrigation possible. In many of the mountains, careless handling of the forests and overgrazing have so damaged the cover of trees, brush, and grass that erosion has long been a serious problem. The lack of frost, which binds the soils of colder climes, and the occasional torrential downpours of rain add to the erosion problem.

Unless care is used to preserve its resources and not carelessly destroy them, after a region has attained a maturity of occupance, it may degenerate and lose its importance in world affairs and its standing in civilization and culture. Parts of the eastern Mediterranean have had this experience. Formerly the region supported dense populations and large cities. Greece, Syria, and Crete, for example, are of minor significance in the modern world, though in ancient times they were centers of civilization. It is believed by some that deforestation, overgrazing, careless use of the land, soil exhaustion, and excessive soil erosion were largely responsible for the decline of civilization in this part of the world.

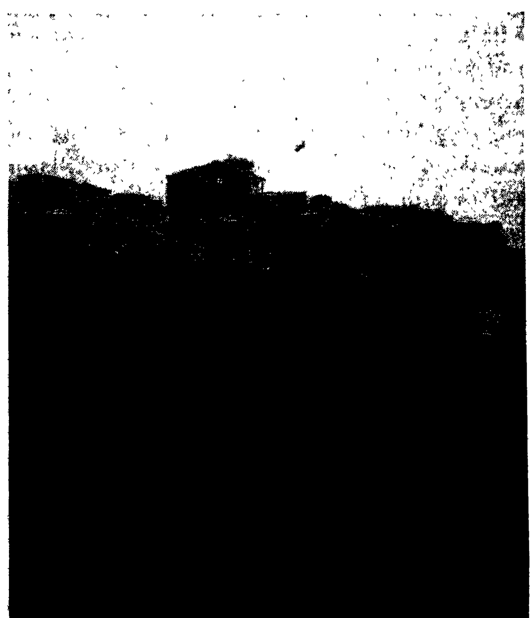

FIG. 91. The fortified city of Grasse in the Maritime Alps of southeastern France. Ancient towns of this type were extremely compact (compare this settlement with the sprawling borders of most American towns). The extensive use of stone for building and of tile for roofs is typical of most European settlements in the Mediterranean areas.

Villages. Locations of settlements around the Mediterranean depend on both natural and human factors. Many of the enclosing mountains near the Mediterranean Sea are largely composed of limestone. This is a soluble rock in which caves often develop, and in such areas much drainage is underground. During the dry summer, many of the streams dry up completely on the surface. Large springs emerge in places from the cavernous limestone rock, and the local inhabitants may depend on such sources for their water supply. The distribution of population naturally is quite uneven in the hilly limestone regions. The custom is to live together in villages from which the people go to till their fields and herd their stock rather than to reside on individual landholdings. In part, this village life resulted from the need for mutual defense during the turmoil and danger of past wars and raids. It continues now because it has become the custom to crowd together into towns. The towns must always have a water supply, and many urban centers have been built near perennial springs. Some old towns have hilltop locations for protection (Fig. 91). At the mouths of rivers little deltas furnish tillable soil to support a city; this is true also of the flood plains of the large rivers and other areas of fertile land. Rich soil seldom covers any part of the country, but where it occurs the population becomes very dense and the land is intensively cultivated, often by hand methods, so that the maximum number of people can find sustenance.

Successive Occupance of California. Man's use of a region varies widely according to his culture and experience. Often different industries or leading occupations follow each other in a regular succession. Parts of California serve as a good example. There the Indians, never present in large numbers, gathered acorns, shellfish, roots, and berries to supplement the rather scant supply of game animals. The Spaniards and Mexicans introduced livestock, vast herds of cattle cropped the natural fodder, and only a little farming was carried on. The Americans were attracted first by the wealth of furs and placer gold but soon turned their attention to agriculture. After a period of "bonanza" wheat farming, irrigation (Fig. 92) was begun, and the large ranches and estates were divided into small holdings intensively farmed for the production of grapes, soft fruits, alfalfa, sugar beets, and vegetables. Together with intensive agriculture and irrigated farming, man has now built large cities and developed the mines, oil deposits, forests, water power, and other resources. Thus in California at present more men are engaged in commerce, manufacturing, catering to tourists, and the professions, than are supported by agriculture, intensive though that may be.

FIG. 92. Basin irrigation of a grove of Valencia oranges in southern California. Fruit flourishes in this frost-free sunny region when the necessary water supply is provided.

The Humid Subtropics

Location and Characteristics. The principal humid subtropical climate areas are found in approximately the same latitudes as those of the Mediterranean regions, but on the eastern coasts of the continents (Fig. 87). The greatest extent of this type of climate is found in the southeastern United States; southeastern Asia, including locations as far north as the southern tip of Korea and Japan; east central Argentina, Uruguay, and southern Paraguay; and a small area occurs in southeastern Australia. These regions experience moderate to abundant rainfall in all months of the year, with greatest concentration occurring in the summer season. Thus they resemble the monsoon climate in distribution of precipitation but lack the winter drought period (Fig. 93). The causes of heavy summer rains in the humid subtropical regions are in large part similar to those producing monsoon conditions—marked differences in pressure and winds, built up between summer and winter seasons over the interiors of continental land masses.

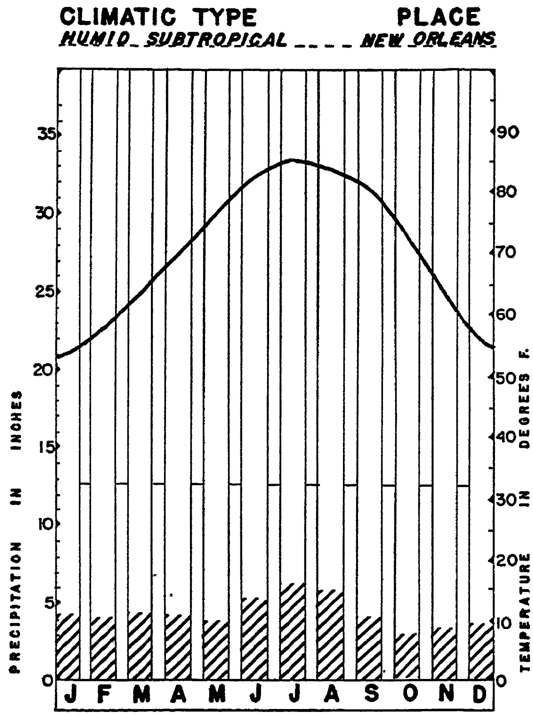

FIG. 93. Climatic graph for New Orleans, Louisiana. The humid subtropical regions occupying the southeastern coasts of continents in the Northern Hemisphere normally experience heavy rainfall throughout the year with a slight tendency toward summer concentration of rain. Temperatures in summer are tropical, and those of winter are moderate. No month in the year has a mean temperature lower than freezing, although there are occasional winter frosts.

Vegetation. Like the monsoon areas, the humid subtropical climate is characterized by long hot summers which are highly favorable for the rapid growth of vegetation. Palms, citrus fruits, cotton, tobacco, and rice, as well as many other typical subtropical crops, may be grown commercially in these parts of the world. Native vegetation may consist of coniferous and deciduous trees. Most of the conifers and many broad-leaved trees, such as the orange and live oak, are evergreen. Typical conifers include the yellow pine of our southeastern states and the Paraná pine of southeastern Brazil. Farther inland in South America are forests of the hard quebracho trees used for making tanning extract and the bushy yerba maté from whose leaves a tasty tea is brewed. Approaching the equator, the broad-leaved vegetation may be evergreen, as in southern Florida, while the palmetto grows as far north as the Carolina coast. The Chinese utilize several varieties of bamboo that thrive in this climate. Grasslands are characteristic of certain regions, notably in Uruguay and Argentina. The coastal prairies of Louisiana and Texas are other examples, along with tall-grass areas in the interior parts of Texas and Alabama.

Climatic Effects. The humid subtropical growing season is long, with an average frostless season of more than 200 days per year everywhere; and this, combined with high summer temperatures, makes these parts of the world highly desirable for human activity, since supplies of food may be procured

without too much difficulty and the rate of productivity is moderately high. The short and relatively mild winters are not serious handicaps to such activities as dairying, fishing, or lumbering. Occasional frost periods of short duration are a menace to commercial crops like oranges and pineapples, but many orchards are protected by heating devices similar to those in Mediterranean regions. These cold waves descend to the latitudes of humid subtropical regions as the wind zones of the earth are pulled equatorward with the approach of the winter season in the Northern Hemisphere, bringing cyclonic storms of low temperature to subtropical locations. Modern methods of weather forecasting often provide sufficient warning so that crops may be protected from frost damage, but in many seasons an entire winter may pass without serious threat of freezing temperatures. Cold waves occasionally bring light snowfall to the poleward margins of the subtropical regions and to interior continental locations in these latitudes.

Rainfall is heavy in this climatic realm, amounting to about 40 inches per year on the average and rising to 80 inches in some years. This amount is sufficient, in combination with high temperatures, to account for extensive leaching of residual soils. When this occurs, the depleted soil must be restored by the addition of large quantities of fertilizer to the fields and orchards. Indeed, the farmers of the southeastern states make heavy purchases of mineral fertilizers in order to maintain the necessary level of agricultural productivity. On the other hand, soils that have been transported from their places of origin by means of the heavy stream flow in this humid climate, where they take the form of river terraces, flood plains, and delta plains usually make exceptionally fertile farm land. Flood plains of the Mississippi, Si Kiang, and La Plata systems, for example, are very productive and highly desirable for agriculture, provided that unfavorable drainage and flood threats can be corrected.

Residents of humid subtropical regions experience long hot summers, particularly on the equatorward margins where high temperatures and high humidity generally are detrimental to human health. Furthermore insect life often makes the summer season unpleasant, and it is difficult to maintain good health conditions. Malaria is prevalent in many sections, especially in southeast Asia; and hookworm and other parasitic diseases add to the health problem. Winters are brief and relatively mild, though the high humidity makes the air seem raw and damp except in coastal locations, as along the east coast of Florida where marine temperatures prevail in winter. Visitors find the winter season more pleasant than summer.

An unfortunate and occasionally disastrous weather condition may occur in humid subtropical regions at the time of the hurricane season. These erratic storms may bring great damage to crops, farm structures, cities, and shipping. Whole seasons may pass without hurricanes, but several storms may strike in a single year. Improvements in forecasting the formation and courses of hurricanes have reduced the losses of life and property to a considerable extent. Hurricanes are usually most destructive along coasts, because the storms tend to subside in the interiors of land masses.

Subsistence Farming. Agriculture in this region has two strongly contrasted aspects: that conducted by somewhat backward and primitive methods, designed to provide one man and his family with most of their daily food requirements; and that based on large landholdings, designed to provide surplus supplies of food for cash sale. Farming at the subsistence level in the southeastern United States involves the production of sweet potatoes, corn, hogs, dairy cows, and small amounts of wheat, fruit, and other foodstuffs. In Argentina, Uruguay, and Paraguay, agriculture is largely on a commercial basis rather than on the subsistence level.

In China and Japan, the subsistence items include peanuts, rice, and fish (as well as poultry, swine, and corn in China). With a growing season from 7 to 11 months long,

two or three food crops can be raised on the same ground each year. Hence a family may require only 1 or 2 acres of ground, which is worked intensively. Farmers sometimes raise two crops of rice annually, or perhaps some winter-sown grain alternates with summer-sown rice, together with a crop of vegetables between each of the grain crops. This is made possible by the practice of transplanting rice by hand from seedbeds in which the crop is started (Fig. 94). This land must be well fertilized if it is to continue at a high level of production, and the waste of cities, "green manure" crops, and sometimes commercial fertilizers are used for this purpose. All three major humid subtropical areas grow rice, but it is a large-scale commercial crop grown with the aid of mechanical devices in the southeastern United States and Argentina. It is, however, not so generally important or productive in humid subtropical regions as in monsoon areas like India.

Plantation Agriculture. Several important essentials must be provided before large-scale agricultural production can be attained. Among other requirements, it is necessary to establish unusually large landholdings, mechanical equipment, excellent transportation facilities, and a large supply of cheap labor. In parts of the southeastern United States and in the La Plata region, large estates or plantations serve as producing units, but this is not the case in Japan and China, where the cultivable land area is extremely limited in relation to the population density.

Tea. Subtropical plantation crops, grown commercially, include tea in China and Japan, where cheap labor and long experience favor its production. Hilly land, not generally useful for other crops, is used for the tea plantations, since the large populations of those lands require most of the fertile lowlands for growing rice and other food crops. Tea is also raised in strictly tropical locations like Java, India, and Ceylon but only in highland sections where cooler nights produce a better quality of leaf than on hot lowlands. Picking of tea is not difficult but requires some experience. Because it cannot be done well with machinery, great numbers of poorly paid natives are employed at this hand labor. Labor costs in the United States or in Argentina are too high to permit profitable production.

Cotton. This fiber plant grows in subtropical regions, both humid and dry, but one of

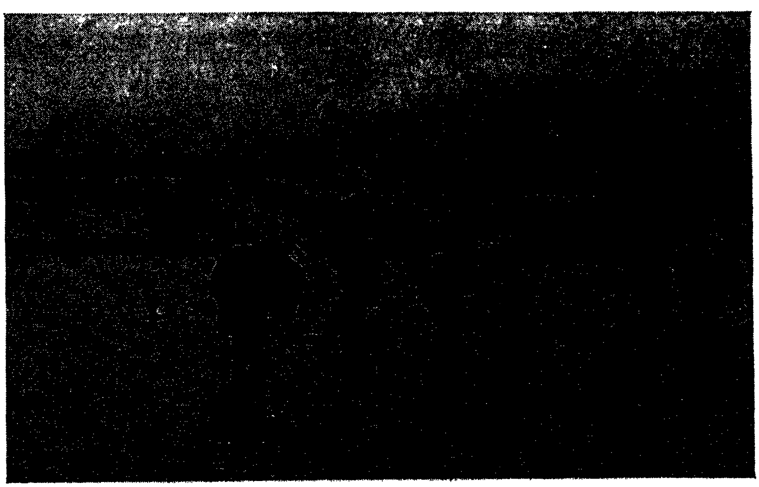

FIG. 94. Japanese farmers planting rice by hand in flooded rice paddies. This type of "stoop labor" is exceedingly tiring, and health conditions are generally affected since the farm laborer is forced to work long hours with his feet and hands immersed. In terms of human effort and time, this is an expensive form of agriculture. (*Photograph courtesy of the American Museum of Natural History, New York.*)

the largest producing areas is in the southeastern states of this country, where the plantation system with its supply of cheap Negro labor was established at an early date in our history. For many years cotton was the leading crop, ideally suited to climate and soil conditions; but the economic collapse of some large southern plantations, combined with the steady spread of the cotton boll weevil (Fig. 61), brought some crop diversification, the introduction of other crops, including tung nuts, peanuts, and deciduous fruit trees, and other developments like market gardening and dairying. Southern Brazil, Paraguay, and northern Argentina are now growing cotton on an extensive commercial scale, though the lack of labor is a handicap. Cotton is grown to some extent in China, where there is plenty of labor, but there it must compete with the growing of greatly needed foodstuffs.

Tobacco and Other Crops. In general, humid subtropical regions lack the high temperatures and long growing season necessary for the successful growth of cane sugar, though other geographic factors seem favorable for its production. Relatively small amounts are grown in China, Argentina, and Louisiana. Tobacco is of greater importance. This was also a western hemisphere plant and is grown for the most part on farms south of the Ohio River, though much first-class cigar-wrapper tobacco is grown in the Connecticut Valley (Fig. 95) and elsewhere in the northern states well outside the humid subtropical climatic region. Both cotton and tobacco require soils of high fertility, plenty of moisture, a long growing season, and cheap field labor for their profitable production. These factors are present in our southern states, and that is the world's most important tobacco-growing area, especially in Kentucky, Virginia, and North Carolina. As yet, Argentina and southern Brazil lack the labor for cultivating tobacco, and China and Japan lack sufficient arable land that can be spared for this crop. Peanuts, grown especially for their vegetable-oil content, are an important plantation crop in the humid subtropical zone of the United States and China, where labor and machinery are available for their cultivation and harvesting. They are relatively unimportant as a commercial crop in Argentina or Brazil.

Other crops of great importance in humid subtropical regions include wheat, corn, silk, and citrus fruits. This climatic type normally is too warm and damp for the best wheat, but nevertheless some is grown in Argentina and in China. In the United States wheat is asso-

FIG. 95. Stringing "hands" of tobacco on racks preparatory to hauling them to the drying shed. Polish farm laborers have taken over much of the commercialized farming of the Connecticut River valley.

ciated with more severe climates. Corn is especially well suited to the humid subtropical realm as a crop grown for human and cattle feed, though it is also grown in large amounts for the oil contained in the kernels. Corn is important in the southern United States, Argentina, and China (in the order of their importance) but not in southern Japan, where land is limited. The long frost-free growing season favors the production of vegetables, strawberries, and other commodities to supply the northern markets in our country before their locally grown produce is available in the springtime.

Silk. This fiber, which is regarded as a luxury commodity in most parts of the earth, is particularly associated with the humid subtropics of China and Japan, where it has been produced for centuries as a household industry. Mulberry leaves are used for feeding the silkworms, and skilled labor is needed for tending them and preparing the fine fibers for market. Silk is not made to any extent in the United States or Argentina, although it would be entirely feasible from the climatic standpoint.

Tree Crops. Tree growth in humid subtropical parts of the United States and China is of much commercial importance. In our South, the softwood forests supply lumber, paper pulp, tar, and turpentine (these industries will be described in Chap. 11). Tree crops include the native pecan of the South, tung oil from China, camphor from Formosa, and the citrus varieties, which are successfully and extensively grown in Florida, southern China and Japan, and Brazil.

Farm Animals. Where dense populations prevail, the concentrated grains are needed for food for the people and cannot be spared for horses; this factor favors the use of the ox or the water buffalo (carabao) for the cultivation of the land and the drawing of carts (Fig. 96). Furthermore animals with cloven hoofs can plow the muddy rice fields better than horses. In the southern states of our country the tough mule is preferred by many farmers for a work animal. The pig is well adapted to utilize wastes for food and is a good rustler for itself in the woods. It is a very common animal grown for food in both China and the southern states. For the amount it eats, the pig puts on more weight than other animals, and it is thus well suited for raising in densely populated countries. In the United States it is particularly related to corn production, and that is its principal food, but

FIG. 96. The carabao, or water buffalo, is readily domesticated and is used extensively throughout the Asiatic tropics. (*Photograph courtesy of the Hawaii Visitors Bureau.*)

hogs are important in all humid subtropical areas. Chickens, ducks, and other poultry are usual adjuncts of farms in the humid subtropics. Dairying has possibilities, but some of the breeds of dairy cows developed in the northern states are not well adapted to conditions in the South, and the development of a special breed of dairy cows is needed for the humid subtropics. Cattle are most important in the southern United States and to a lesser extent in humid subtropical Argentina and China, in that order.

The Variable Climates of the Stormy Westerly Winds

More than half the world population lives in the middle latitudes. This suggests that the greater variation of temperature experienced there, the distribution of rainfall, and other natural conditions are unusually favorable for man. The most powerful countries of the world today are situated in middle latitudes, including most of Europe, the United States and southern Canada, and the Soviet Union. The most progressive countries and peoples in low latitudes are those situated in altitudes high enough to give lower temperatures that are favorable to man.

In the tropics parallel zones of climate and natural vegetation generally extend in an east-west direction, and the broad belts of different climates are largely classified by decreasing rainfall from the doldrums to the trade winds. In the middle latitudes the climatic zones in general extend in north-south belts across the continents and are marked especially by rainfall differences and natural vegetation. Even the isotherms frequently do not parallel degrees of latitude all the way across a continent. From the equator to the mid-latitudes, isotherms roughly parallel the latitude lines, but in the realm of the prevailing westerlies the annual isotherms on west coasts are farther away from the equator than in the interiors and east coasts of continents—the result of oceanic as compared with continental influences. Even greater contrasts occur between summer and winter isotherms on west coasts compared with those of the continental interiors.

West-coast Marine Climate

On the west coasts of continents, abundant rains occur throughout the year in the middle latitudes, with maximum precipitation in the winter months. This results from the prevailing westerlies and the associated cyclonic storms coming from the oceans toward the shores of the continents. The cyclonic storms are especially well developed in the fall, winter, and spring. The temperature shows a small range between winter and summer, providing generally mild winters and cool summers (Fig. 97). Transition periods in the spring and autumn provide four distinct seasons during the year. This oceanic climate on the west coasts extends far inland in Europe where no north-south trending mountain ranges serve as climatic barriers (Fig. 98).

In North and South America, on the other hand, high mountains parallel the Pacific near the coast, and the areas of heavy rainfall and mild marine temperature variations are limited to the narrow littoral. To leeward of the mountains, continental conditions prevail, with great extremes of temperature and limited rainfall. The abundant rainfall of a west-coast climate supports dense forests of both hardwoods and conifers. The conifers include the Douglas fir, cedar, spruce, and western hemlock in northwestern North America, but in Europe the "summer" woods of deciduous trees cover much of that continent between the Mediterranean region and the northern coniferous forests of Scandinavia and Russia. The higher hills and mountains and areas of poor sandy soil also support conifers in the mid-latitudes of Europe. The South Island

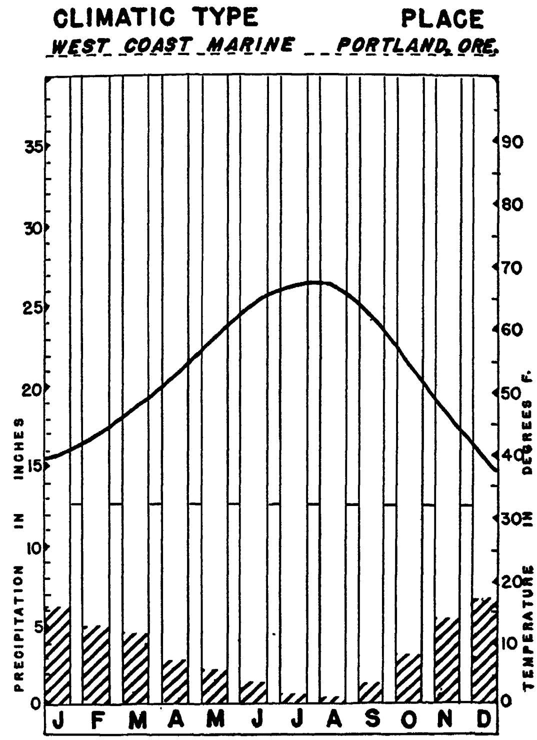

FIG. 97. Climatic graph for Portland, Oregon. A West Coast marine location in the mid-latitudes of the Northern Hemisphere. Note particularly (1) the moderate seasonal temperature variation, with no month in the year having a mean temperature lower than freezing, and (2) the moderately heavy rainfall occurring in all months of the year, but with a tendency toward a maximum in the winter season. These conditions are related to nearness to the sea.

of New Zealand has high mountains along its west coast where dense forests grow, while on the eastward side grasslands are extensive.

Northwestern Europe. Western Europe includes the most highly developed portions of the continent and supports 250 million people in an area not so large as the United States east of the Mississippi. Although deposits of coal, iron, and other minerals favored manufacturing and the irregular coast line and navigable rivers favored the expansion of ocean shipping (in both of which endeavors western Europe leads the world), the most important factors in the development of the region are the favorable stimulating climate, extensive plains, and fertile soils lying in the stormy westerly winds. Here the combination of geologic and geographic factors has led to the growth of great states, industrial cities, and dense populations. The western part of Germany, most of France, all of Belgium and the Netherlands, the British Isles, and Denmark enjoy this climatic type. Summers are relatively cool and moist, with plenty of rain for the growth of trees and grasses. Though originally well forested, Europe's virgin forests have long since been utilized by man. The growing season is long, and winters are mild, especially in relation to the latitude. With plenty of excellent forage dairying flourishes, and in fact the concentration of dairying in the Netherlands and Denmark almost provides those nations with what might be regarded as a national economy. Dutch cheeses from Alkmaar and Danish supplies of butter and milk-fed bacon are favorably known in most parts of the world. Sheep are important in the farm landscape of this part of the world, and as a dual-purpose animal, supplying both meat and animal fiber, they are grown widely though seldom in large flocks. Fishing is an important occupation in all the marine west-coast regions of Europe.

Other important agricultural activities in northwestern Europe include the production of some grains, especially wheat in the less humid sections; and rye, oats, and barley. Northwestern Europe, however, is not prime grain country compared with other parts of the world. It grows some mid-latitude fruits, including grapes and apples; the latter are famous in northwestern France. Beet sugar is commonly grown, and hops and some flax. These crops provide most of the foodstuffs for western Europe's large urban and industrial population, whose nonagricultural activities include the exploitation and use of a wealth of raw materials and potential energy, especially coal, iron ore, and hydroelectric power. These, with skilled labor, combine to provide Europeans with necessary supplies of steel, rayon, and other fabrications related to advanced industrial states.

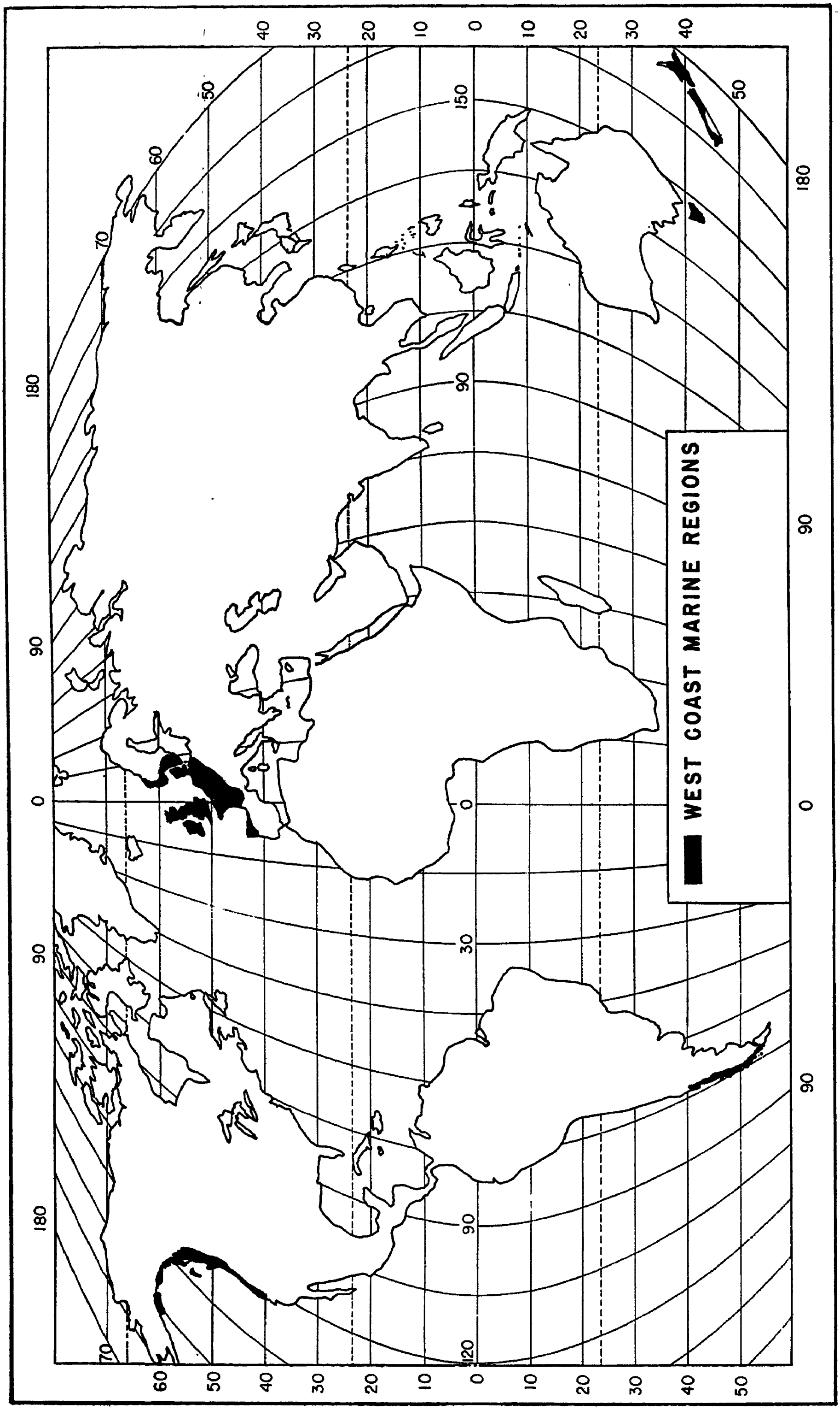

Fig. 98. West Coast marine regions of the mid-latitudes.

The Pacific Northwest. Mid-latitude marine regions outside of Europe, however, are comparatively undeveloped. The climatic type in North America is limited in extent because the Cascades and Coast Ranges of the Pacific lie so near the sea that only small areas of land are favorable for agriculture. These include the Willamette Valley and the Puget Sound lowland of western Oregon and Washington, where cattle and sheep raising, dairying, growing tree fruits and small fruits, poultry raising, and a little grain production are the principal human activities in the rural sections.

Away from the lowlands, in the mountainous regions, the remarkable stands of timber in the Pacific Northwest permit Oregon and Washington to lead other states of the nation in lumber production (Fig. 99). About 60 per cent of all wage earners there are employed in the forests and woodworking plants. Cities like Seattle and Tacoma started as lumber-mill towns, and the industry is still important. Most sawmills and paper mills are located on tidewater for convenience of receiving and shipping raw materials and finished goods. Puget Sound has many sawmill centers, including Bellingham, Everett, and Port Angeles. Aberdeen and Hoquiam are situated on Grays Harbor, and Longview and Vancouver on the Columbia River. All have their large mills (Fig. 100). In Oregon, Coos Bay and the inland cities of Eugene, Bend, and Klamath Falls are important sawmill centers.

The canning of salmon and the processing and storage and shipment of halibut and other fish are also important on the Pacific coast, from the Columbia River to Alaska.

The presence of large supplies of hydroelectric power is an advantage in this region, for it lacks the wealth of coal and iron ore found in northwestern Europe.

Indians of the Pacific Northwest Coast. Native peoples are repelled by the dense dark forests of these regions. On the west coasts of middle latitudes few large wild animals live in the forests to provide food for hunters; furthermore, because of the dampness of the forests and the large size of the trees, it is very difficult to clear the land either by fire or by primitive stone axes. As a result, the greater number of the natives originally lived along the coast and looked to the sea for their livelihood. Only civilized man possesses the knowledge and equipment to use the available resources of land, fish, and timber in large-scale industry.

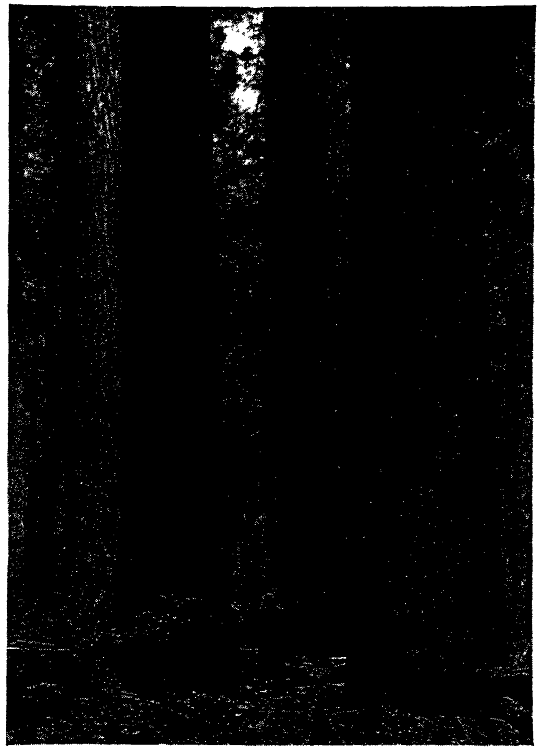

FIG. 99. Virgin stand of Douglas fir in the Pacific Northwest. This forest is exceptionally free from undergrowth and undesirable timber. (*Photograph courtesy of the U.S. Forest Service, Department of Agriculture.*)

The American Indians from the mouth of the Columbia River to the southern coast of Alaska practiced no agriculture and lived on fish and other sea food, supplemented to a small degree with game and berries secured from the land. The villages were built near some stream up which the salmon migrated or at other favored locations convenient to the fishing grounds. The Indians lived in houses

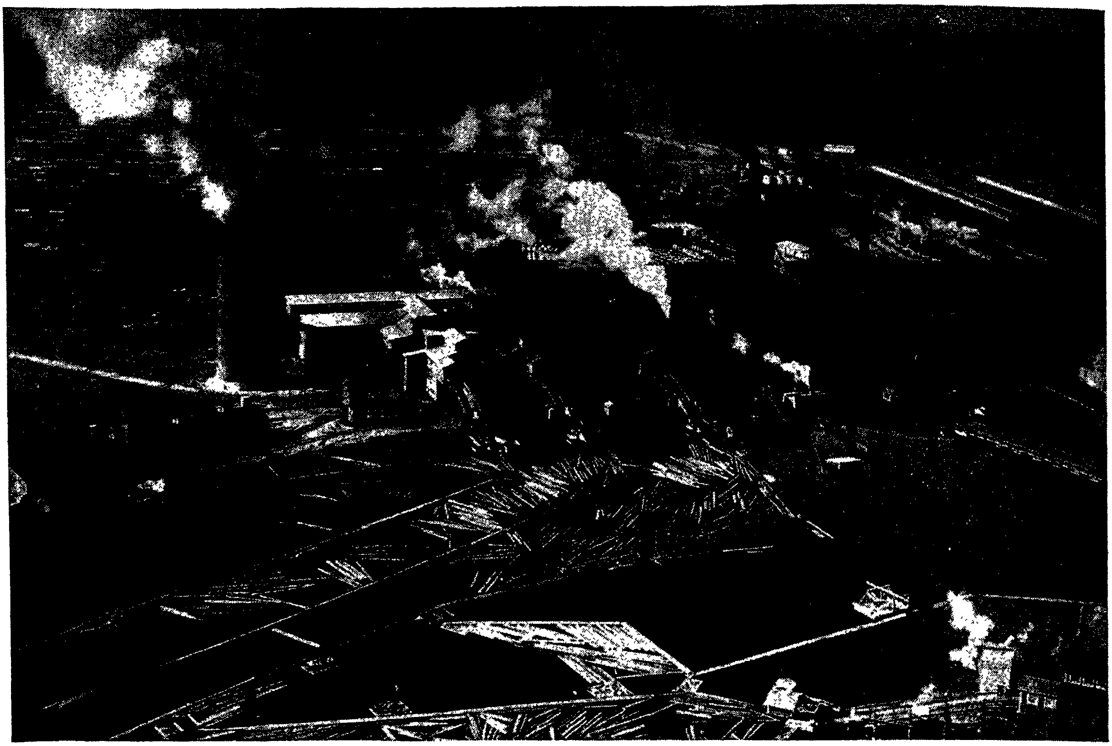

FIG. 100. Lumber mill at Bend, Oregon, in the Pacific Northwest, showing a large log pond and storage yard for sawed lumber. Refuse is burned in the large incinerators. This mill has its own water supply and fire-protection system, as the overhead tanks indicate. (*Photograph used by permission of Brubaker Aerial Surveys.*)

built of hand-split cedar boards and they carved large seaworthy canoes (Fig. 101) from big cedar logs with fire and primitive tools. Large carved and painted totem poles were erected by some of the Indians.

The Indians of the Queen Charlotte Islands and other places along the Northwest coast traded extensively with each other and thought nothing of making voyages of many hundreds of miles in their large canoes, especially within the protected waters of the Inside Passage from Alaska to Puget Sound. The Indians cared little for penetrating the interior. The forests furnished material for houses, boats, fuel, and other needs. Fur-bearing animals like the otter, fur seal, bear, and beaver were common in the shore waters or forests and furnished clothing and furs for export trade. The salmon that ascended the streams in almost incredible numbers were caught and cured for winter use and furnished a reliable food supply.

Southern Chile. Southern Chile has limited areas for agriculture because of the Andes, which, like the Cascades of the Northern Hemisphere, prevent the stormy westerly winds from penetrating far inland. It is relatively unpopulated and unproductive, though possessing large amounts of water power and dense forests. Southern Chile has been a comparatively recent frontier of settlement, and its agriculture and industry have been retarded, partly because of its remote location from world centers of trade and population, and partly because of the presence of very hostile Indian tribes. It is a land of small villages, out of contact with the populous part of Chile, and experiencing a climate and soils that are highly unfavorable for intensive agriculture.

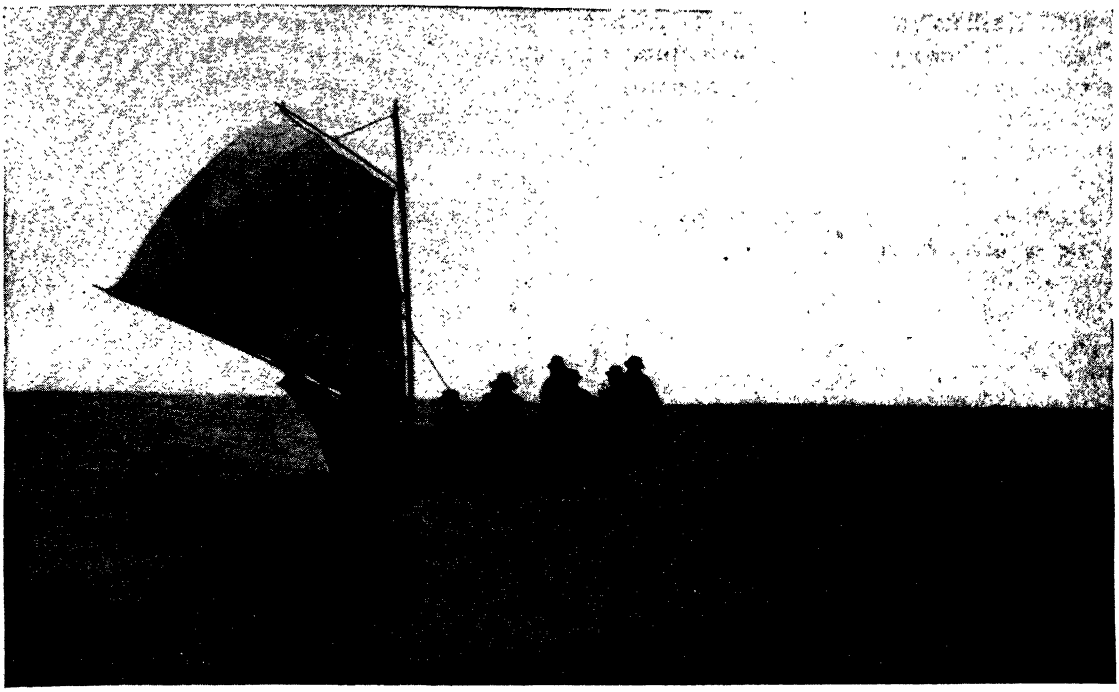

FIG. 101. Makah Indians in a Northwest Indian canoe shown towing a whale in the open Pacific 15 miles from the entrance to the Strait of Juan de Fuca. (*Photograph courtesy of the Washington State Historical Society.*)

New Zealand and Australia. The islands of New Zealand and a limited area in southeastern Australia lie within the path of the Southern Hemisphere westerly winds and receive the full effect of marine conditions. They, like southern Chile, are remote from centers of population, but the presence of volcanic mountains has helped them with some excellent agricultural soils of limited extent. Their people are occupied largely in grazing operations of some magnitude, with both sheep and dairy cattle. The meat, butter, cheese, wool, and other products that they grow beyond their own needs find ready markets in the cities of northwestern Europe, where population is too great in relation to local supplies of food. New Zealand's markets for animal products, it should be noted, are largely dependent on improvements in refrigeration and rapid transport by sea. Without these developments, it is difficult to compete with more favorably located areas such as Denmark. New Zealand also has excellent supplies of water power, but like southern Chile she lacks the raw materials needed to make their use effective.

Arid and Semiarid Continental Interiors

The Climate. Interior parts of continents in the middle latitudes customarily experience great temperature ranges, because marine conditions are unable to penetrate the centers of large land masses (Figs. 74 and 77). In parts of central Asia, for example, the average temperature for January may be 80°F. lower than that for July. Rainfall is generally scanty and of high variability in amount from year to year, for moist sea air seldom reaches these regions. Most rainfall occurs in summer as the result of local convectional thunderstorms, but it is seldom sufficient to provide for more than the growth of scant supplies of grass. Upon

some occasions in summer, rain may come from an inflowing damp air mass from the cool ocean during the period of greatest heating, but rainfall usually decreases inland from the sea as the "supply" of moisture is precipitated from the air masses.

Location. Locally, mountain ranges of moderate or great height may account for some increase in the amount of rainfall. Where the interiors of continents lie to the leeward of mountains trending athwart prevailing winds from the sea, "rain shadow" deserts and semiarid steppes are found. The steppes may be transitional between the deserts on the one hand and the forests or well-watered prairies on the other. Other grasslands or steppes are in localities that have deficient rainfall but are not so dry that desert conditions prevail (Fig. 102).

North American interior dry lands occupy broad basins and plateaus from the Columbia Basin in Washington and Snake River Plain in Idaho southward through the Great Basin of Nevada and Utah and across New Mexico into old Mexico. East of the Rockies the rolling steppes called the Great Plains extend from Alberta and Saskatchewan across the whole width of the United States into north-central Mexico. Somewhat similar dry grasslands are found in southern and western Argentina. Interior deserts and steppes, including The Gobi, Takla-makan, and Turkestan regions, spread over large parts of Asia and extend into southeast Russia (these regions have been described in some detail in Chaps. 8 and 13). Iran, Afghanistan, western and northwestern China, and adjacent parts of the U.S.S.R. are included in the lands in which sparse rainfall is a dominant environmental factor. Over extensive parts of interior Asia, temperature ranges are extreme and winters long, adding to the difficulties of the inhabitants. Extensive subtropical steppes occur in North Africa, South Africa, and on the uplands of East Africa; here the geographical conditions are more favorable for human use of the land because of the considerable altitude. In Australia the grasslands are transitional in location between the interior desert and the forests found along the east, southeast, and southwest edges of the continent.

Landscapes. The surface appearance of deserts differs little whether their location is in the tropics or the mid-latitudes. The same statement is in general true of steppes or grasslands in different latitudes, although wintry scenes seasonally characterize the landscapes of the interior parts of continents in the mid-latitudes.

The hills and valleys tend to have steeper slopes under arid and semiarid conditions than under humid conditions. There is an angularity to the relief features of dry lands in contrast to the more subdued and rounded contours of the surfaces formed in rainy climates. The landscapes of these interior regions are usually barren of tree growth except in locations where sufficient subsurface stream flow provides water for small groves—a condition corresponding to the oases of deserts. Grasslands occupy most of the semiarid continental interiors, and wood for fuel and building purposes is difficult to obtain. If rainfall is sufficient, a tall grass may prevail, forming a heavy sod, or prairie. Light and irregular rainfall produces the short grass and scattered bunch grass that characterize the steppes.

There is seldom enough precipitation in the mid-latitude steppes to provide many surface streams. These are usually small in flow, few in number, and set within low steep-sided banks. Tributary streams are not numerous. Stream channels of this type frequently have a greater flow of water underground than on the surface, and their beds may be tapped with relative ease with excavations, pipes, or other means for the use of stock or for small irrigation projects. It is difficult, however, to use these stream channels to impound water for irrigation, because their banks are too low and basins too broad and shallow to provide satisfactory sites for reservoirs. Melting snows on nearby mountain ranges may provide some

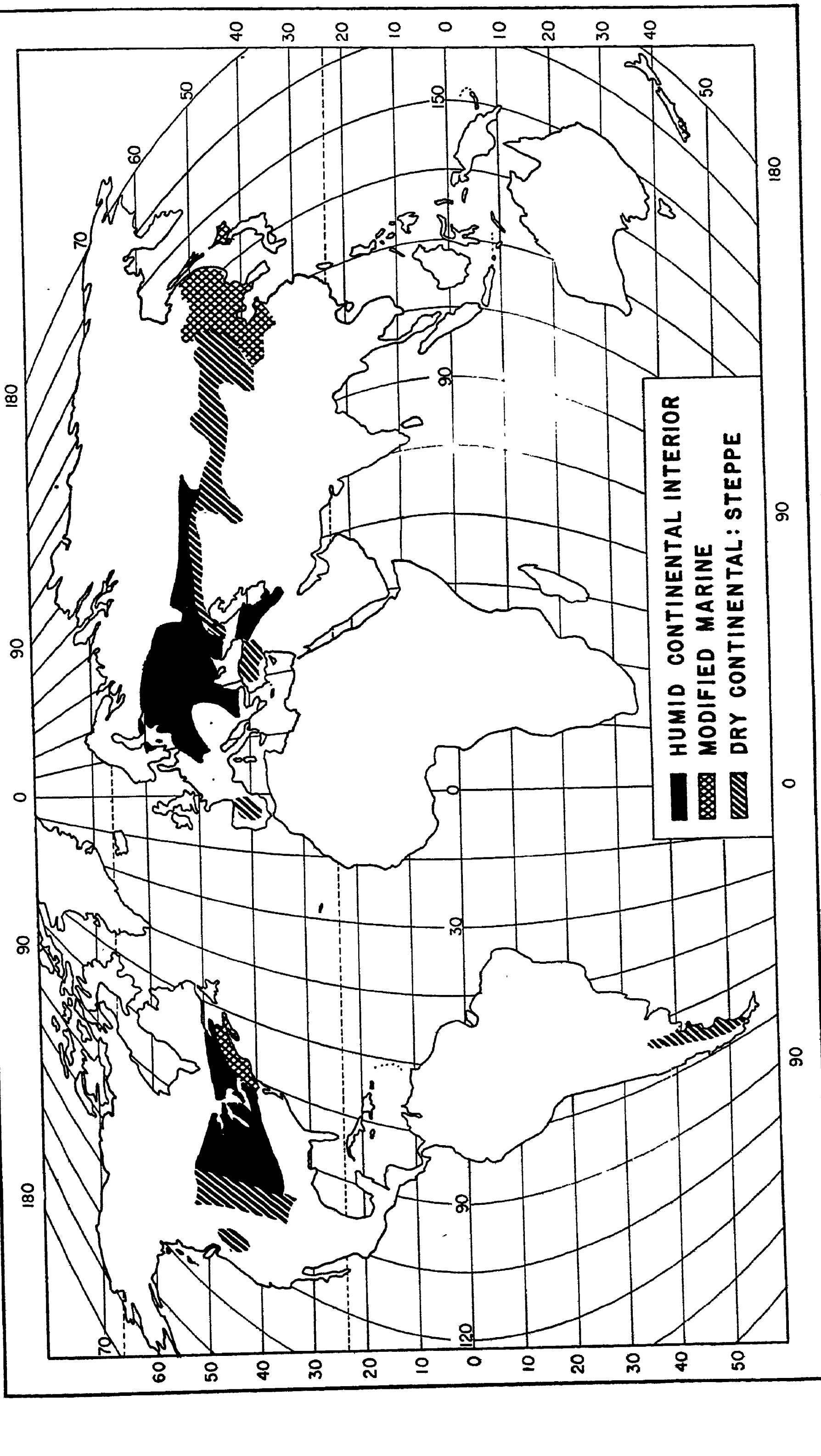

FIG. 102. Mid-latitude climatic regions.

water for irrigation purposes on dry-land areas.

Man's Use of Steppes. Originally the steppes of the middle latitudes were the native habitat of great numbers of wild animals, feeding upon the characteristic short grass and free to roam without hindrance over the plains, seeking water holes and forage. Attracted by the abundant meat supply, peoples of the steppes are typically hunters. Thus in Patagonia on the grassy plains east of the Andes in southern Argentina there once roamed herds of guanaco, a cousin of the camel and the llama. Here certain Indians subsisted on its flesh and used its skin for clothing and shelter. Likewise in Africa some tribes depended for support mainly on the vast herds of wildlife living on the grasslands. In North America and parts of Asia the same conditions prevailed, for primitive hunting was the principal occupation of many tribesmen on the steppes. Now, often enough, the grasslands serve for the grazing of domestic livestock and the cultivation of drought-resistant grains on an extensive scale. When man uses the steppes more intensively than for hunting, he changes the type of animal, replaces much of the native plant life, and modifies the landscape, as indicated in Fig. 103.

The Plains Indians. The Indians of North America who originally lived on our central prairies and Great Plains relied upon millions of buffalo (bison) (Fig. 104) and great herds of antelope, elk, and other game. The whole life of the Plains Indians was wrapped up in the buffalo as thoroughly as that of the Arab in his camel. The buffalo was hunted in a cooperative way by all the men of a village; and great numbers of the big game might be secured on some hunts, with both weapons and other schemes such as driving herds of buffalo over cliffs where they might be killed by the fall or injured so that they could be dispatched easily.

No part of the buffalo was wasted by the

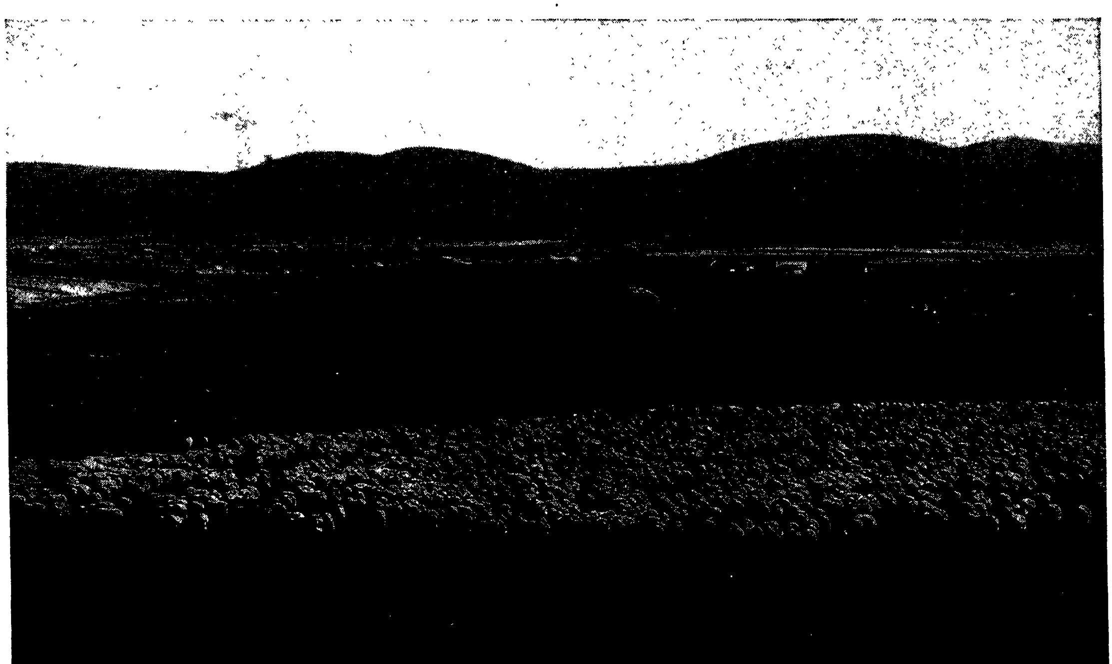

FIG. 103. Flock of ewes pastured in the irrigated lowlands of Kittitas Valley on the eastern slopes of the Cascade Range, Washington. The forage in this steppe landscape is excellent. (*Photograph courtesy of the U.S. Soil Conservation Service, Department of Agriculture.*)

FIG. 104. Herd of bison in Niobrara Wildlife Refuge, Nebraska. Short grass of the foreground is typical of the natural vegetation cover of the Great Plains. Note the expanse of level grazing land of the distant plains. (*Photograph by G. A. Amundson, used by permission of the U.S. Fish and Wildlife Service, Department of the Interior.*)

Indian. Its meat was dried and smoked for winter use. Many of the internal organs furnished needed vitamins in the diet of the Indian. Warm robes were made from the skins, and excellent durable buffalo hides suitable for portable tepees, wearing apparel, and other uses were secured after the hair was removed from the hide. Sinews from the animals served for thread, splinters of bone as needles. The same weapons that were used in fighting the buffalo could be used for fighting human beings. The Plains Indians were accustomed to cooperating in the buffalo hunts; and, when threatened by white aggression, different tribes and villages joined together for war and offered a better defense against the encroachment of white men than did most of the Indian tribes. Originally they possessed only one domestic animal, the dog, used mainly in hunting, although it also pulled burdens supported by sticks dragging on the ground. This device was called a travois. In time of emergency the dog even served as a source of food supply. The introduction of the horse by the Spaniards improved the situation of the Plains Indians. The tribes, when supplied with horses, could travel farther on hunting expeditions, and the men could move their families and camp paraphernalia more quickly and easily.

White Penetration into the Great Plains. When people of European descent entered the Great Plains, they had to adapt their activities to the new environment before settlement became permanent. The Spaniards made little progress against the Plains Indians, who were fierce fighters and possessed too great mobility to be overcome with ease. Not until Americans exterminated the buffalo were these roving nomads restricted to reservations. The white man's plow, introduction of domestic cattle, and the fencing of the plains completed the change within one man's lifetime from a wild Indian and buffalo country to the brief years of open cattle range, and then to the days of the homestead and permanent farming.

American colonists surging westward from the Atlantic coast crossed the Appalachian ridges, carved out homes for themselves from

the hardwood forests, and finally reached the prairies. There, by the development of large breaking plows pulled by many head of oxen or horses, the prairie sod was broken up and its soil proved well adapted to corn, wheat, and other crops. New homemakers kept on beyond the Mississippi through Iowa and Missouri to eastern Kansas and Nebraska and finally to the western parts of these states.

Following the Civil War period, cattle had been driven north from Texas for shipment east to the packing centers and for stocking the virgin-grass empire of the central and northern Great Plains. During the late 1870's and early 1880's, in years of somewhat plentiful rainfall, the first influx of farmers came to compete with the stockmen. Many of these settlers, however, fell into difficulty with the coming of a series of dry years, hot winds, plagues of grasshoppers, and hordes of locusts. Many settlers failed and left the country.

Later the survivors, along with other immigrants. learned how to raise crops on the semiarid plains by conserving moisture by dry-farming methods and the use of seeds that would withstand droughts and severe winters. For example, wheats raised in the humid eastern United States were found unsatisfactory for planting on the Great Plains, and wheat raising became successful only when sturdy winter and spring varieties were introduced from Russia (Fig. 105). Alfalfa proved to be a substitute for the red clover of the East. Grain sorghum, and certain drought-resistant varieties of Indian corn or maize helped overcome the difficulties of the farmers and furnished grain and fodder for their use. Unfortunately too much of the steppes or short-grass lands were plowed up, and sometimes, when cycles of dry years followed, the sod that formerly held the soil in place was destroyed. High prevailing winds then did much damage by drifting and blowing the soil away. Sometimes dust storms covered such vast areas that the topsoil from entire farms or sections of land was blown off and carried

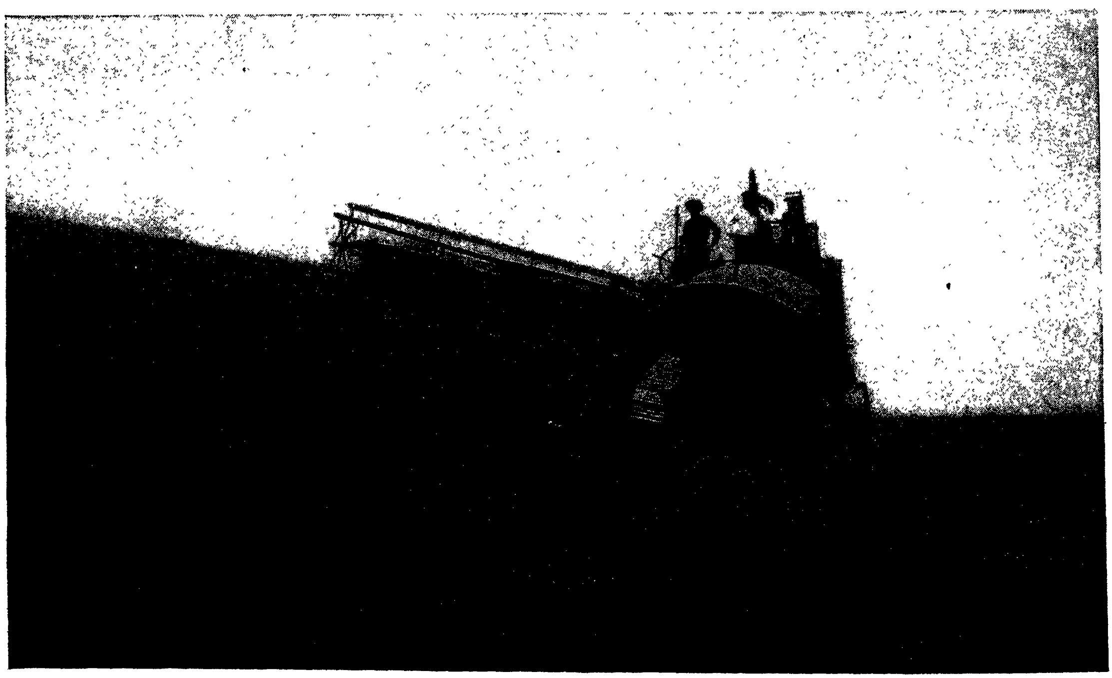

FIG. 105. Caterpillar tractor with an 18-foot combine in eastern Washington. This combination can plow 1,950 acres, harrow 5,000 acres, and cut more than 2,000 acres of wheat in one season. (*Photograph courtesy of the Caterpillar Tractor Company.*)

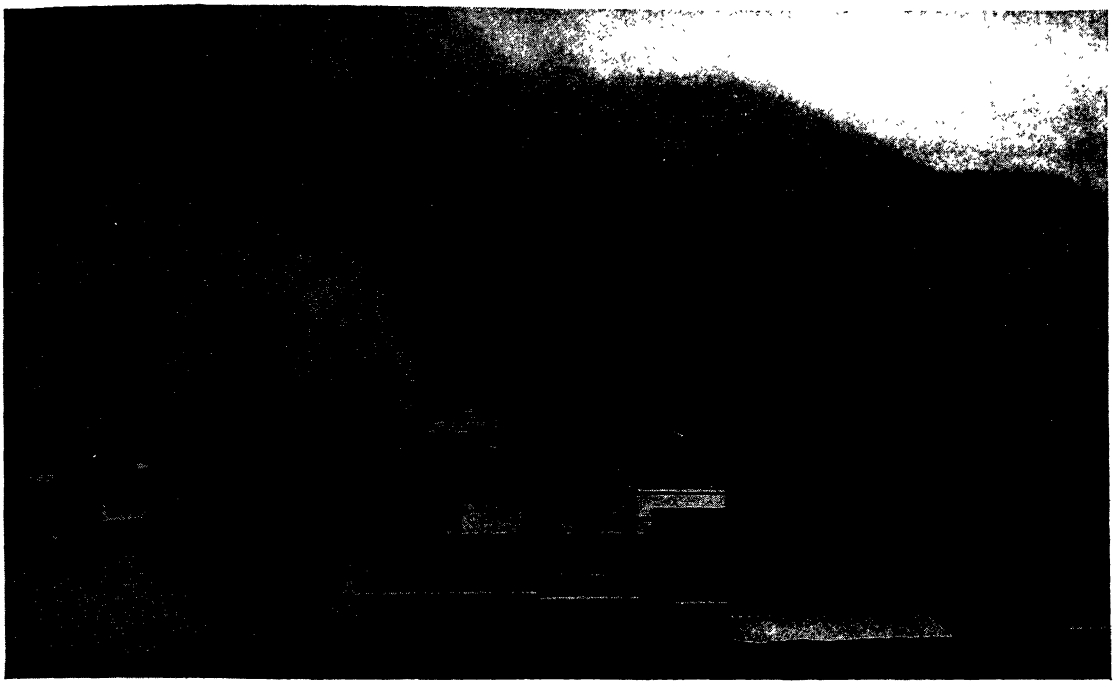

FIG. 106. Dust storm in Clayton, New Mexico. On the day of the storm the weather was calm with light winds from the southwest. The dust rolled in on a light wind, followed by a severe hurricane lasting about three hours. This heavy dust cloud was suspended in the air about half an hour. (*Photograph courtesy of the U.S. Soil Conservation Service, Department of Agriculture.*)

to leeward (Fig. 106). Dust even reached the cities along the Atlantic seaboard. Experiences such as these caused some of the cultivated Great Plains to be abandoned by settlers.

For permanent occupancy, a natural cover of grass, herbs, and other vegetation must be replanted on soil most subject to blowing. Some of the land that is least adapted to cultivation must be returned to grazing use. Careful control should be exercised over flocks and herds so that their numbers shall not exceed the carrying capacity of the grazing lands, with resulting injury to the natural grass cover. By carefully farming the best land, by reseeding the natural grazing lands, and by irrigating where possible, the "dust bowl" and other Great Plains areas that have been damaged by overgrazing and careless working of the soil can be reclaimed.

Mid-latitude Steppe Lands of South America and Eurasia. Unlike the United States and Canada, the steppe regions of Patagonia are not large producers of wheat, in part because their extent is somewhat limited, and in part because they represent a relatively unsettled and nonagricultural frontier whose agricultural capabilities have not yet been exploited. Patagonia, however, does support large numbers of cattle and sheep, on a basis similar to the United States "cattle kingdom" of the Great Plains during the 1870's.

In Eurasia, the Soviet Union has greatly increased the farming of wheat on an extensive scale in recent years, partly through the device of the collective farm, and partly by means of the introduction of modern mechanized methods of cultivation. New railways and highways have been built to facilitate the shipments of wheat to other parts of the nation, especially in the plains lying east and northeast of the Caspian Sea. Farther west, along the lower Volga and into the Ukraine, the steppes have been Russia's principal source of wheat for many years, but methods

of production were relatively backward. As in the United States and Patagonia, the Eurasian steppes produce large numbers of cattle and sheep and, in addition, goats for Russia's needs.

The Hungarian steppe lands are cultivated both for wheat and corn and for the support of beef cattle, milch cows, sheep, and swine. Steppes occupy interior Turkey (Anatolia) and the larger part of Iran (Persia). Sheep and goats are the typical livestock, and drought-resistant grains like barley and wheat are raised where the rainfall is favorable or irrigation can be practiced.

Regions of Humid Continental Interior Climate

The Climate. This climatic type is limited for the most part to the middle latitudes of continental interiors in the Northern Hemisphere, since no large continental masses in the Southern Hemisphere extend into mid-latitudes (Fig. 102). The continental position implied in the name of the climate indicates dominance of temperatures whose wide range indicates pronounced lack of marine influence. Winds, prevailingly from the west but governed by cyclonic circulation, swing into the centers of the continents, bringing sudden weather changes, especially in the winter season when masses of cold polar air migrate into these latitudes from time to time. Rainfall usually is moderate in amount and distributed throughout all months in the year with regularity.

In winter precipitation takes the form of heavy snows, but in summer masses of air move inland from the sea and supply much rainfall, frequently in connection with summer convectional thunderstorms (Fig. 107). Winter rain and snow are mainly of cyclonic origin; and, as the lows approach and move eastward toward the coast, masses of moisture-filled air are drawn inland, furnishing rain or snow to the interiors of the continents.

Temperatures, as already noted, tend to vary widely with change of season, and in this climatic type, extreme ranges of 100° or more may occur between absolute summer and winter maxima and minima. In general, the more southerly parts of the humid continental interior realms have longer and warmer summers while the northern boundaries experience very short growing seasons and long severe winters. Some modification of temperatures occurs on the eastern borders of the region, where winters and summers are slightly less severe because of nearness to the sea, as in New England.

Location. Those parts of the world which experience the humid continental interior

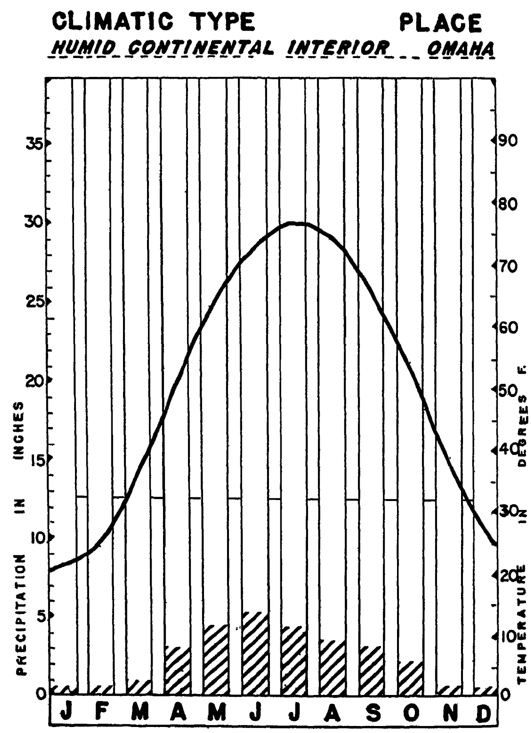

FIG. 107. Climatic graph for Omaha, Nebraska. This location is continental, and the climate is humid. Some parts in the interior of continents in the Northern Hemisphere receive moderate well-distributed rainfall and snowfall throughout the year. Here (1) rain or snow occurs each month, (2) the total amount of precipitation is moderate, and (3) the seasonal temperature range is marked, with at least one month in the year experiencing a mean temperature below freezing.

climatic condition are central North America east to the ocean; central Eurasia; northern China including Manchuria; most of Korea; and southeastern Siberia and the northern part of the Japanese archipelago, especially the island of Hokkaido. Of these, North America is divided into the mild phase where the humid continental interior borders the northern edge of the humid subtropical regions along the Ohio River, and the severe phase experienced in the northern states of Michigan, Minnesota, and the Dakotas. Slight marine effects on temperatures are noticeable in the humid continental climate of New England. Some temperature modification also results in the vicinity of the Great Lakes.

Farms and Forests. The humid continental interior with long summers and relatively mild winters in the United States is a highly productive region. Its soils, partly laid down by glacial or glaciofluvial action, are generally of good quality for mixed farming. Winter wheat is a specialty crop, and the growing season is sufficiently long and warm for the production of large quantities of corn. Oats, sugar beets (in the more arid parts), apples, and other typical mid-latitude crops are important, and dairying is a common occupation. Forests were extensive, and they still provide some timber from both hardwood and softwood broad-leaved trees. Since the soil developed under broad-leaved trees is usually of good fertility, a large part of the hardwood forests has been cleared and the land devoted to farm crops. Open glades, originally covered with the tall grass of the prairies, have been plowed to provide some of the richest granary lands in the nation. Mixed farming, a combination of crops and livestock, is a principal human activity, and the wealth of resources is so great that there has been a marked tendency toward the development of city life with its accompanying industrialization.

Humid continental regions experiencing short relatively cool summers and long severe winters extend in North America from the upper Mississippi Valley eastward into New England. These sections originally were well forested, but, unlike the milder phase of this climate, the trees consisted largely of conifers, growing in soils of only moderate productivity. Manufacturing in this region today is based partly upon forest resources, as at Grand Rapids, Michigan, traditionally a center of furniture making.

Use of the Humid Mid-latitude Forests by the Indians. Among the original native inhabitants in the eastern Americas, the Iroquois Confederacy had the strongest tribal organization. These Indians occupied a very strategic pass route in the Mohawk and Genesee valleys between the Hudson River and the Great Lakes, within the area covered by the severe phase of the humid continental interior climate. The Indians lived in villages, the largest of which contained up to two or three thousand persons protected by strong stockades and trenches. They built community houses more than 100 feet long, with accommodations for 20 families. Such a "long house" was built of logs and bark with separate apartments for the families (Fig. 108). Near the village were fields of several hundred acres devoted to maize and fruit trees, each family having its own plot of land to cultivate.

Elsewhere in the eastern area the Indians were also supported by a combination of farming and hunting. Although land trails connected the villages, journeys were more commonly made by canoe, utilizing the splendid system of glacial lakes and rivers. The light graceful birchbark canoe, perfectly adapted to the rapids, portages, and waterways, was a product of its environment. Besides game and corn, other sources of food were sometimes used. Thus the Winnebago and other tribes of Wisconsin and Minnesota depended largely upon the wild rice that grew in shallow water rather than upon the cultivation of maize.

Present-day Occupations in the Humid Continental Regions. Mixed farming occupies the farmers of the northern states today; their activities are based upon hardier grains than

FIG. 108. Model of dwellings of the Iroquois Indians. The stockade, built of vertical palings, surrounds the bark huts. One of the huts is shown under construction. (*Photograph used by permission of the U.S. National Museum.*)

those which do well in Kansas, Illinois, or Indiana. These grains include spring wheat, grown on the more fertile areas; and rye, oats, and barley on the less fertile soils. Some wrapper tobacco of high quality is grown as a specialty crop. Many fruits, tomatoes, and other vegetables are produced for processing. Cattle, sheep, and hogs are the staple farm animals, though cattle must be stall-fed in winter and losses of sheep may be serious during the most severe winter seasons. Farmhouses and barns must be substantial structures to give adequate shelter during winter (Fig. 109). Originally the trapping of furs was important in northern Michigan, Minnesota, Wisconsin, and parts of the Canadian provinces of Ontario and Manitoba, but this resource is relatively exhausted.

In the extreme northeastern parts of the humid continental interior regions, along the New England coast, human activities are less concerned with farming, because this is a section of the country that was intensely scoured by the action of continental glaciers. Soils are thin and poor, and the climate is too cold and the growing season too short for most grains. Here the people are engaged in dairying and forestry on a large scale, with fishing important along the coast. Some deciduous fruits such as apples are grown, and the staple food is often the potato. Aroostook County, Maine, has achieved economic success by specializing on the production of potatoes. The Annapolis Valley in Nova Scotia is likewise famous for its apples, a type of agriculture made possible by locally good soil and climatic modification afforded by the Bay of Fundy. Furs are important as a special source of income, but in general nature's resources are inadequate to support many New Englanders, and they have turned to industry and manufactures, utilizing the great numbers of waterfalls that are found along the glaciated stream valleys. Raw materials for processing are often imported from other states and countries in quantity, and the coastal parts of the New England states have become important centers of manufacture and highly urbanized. The "back country" remains essentially undeveloped and rural, with dairying and subsistence farming providing a livelihood.

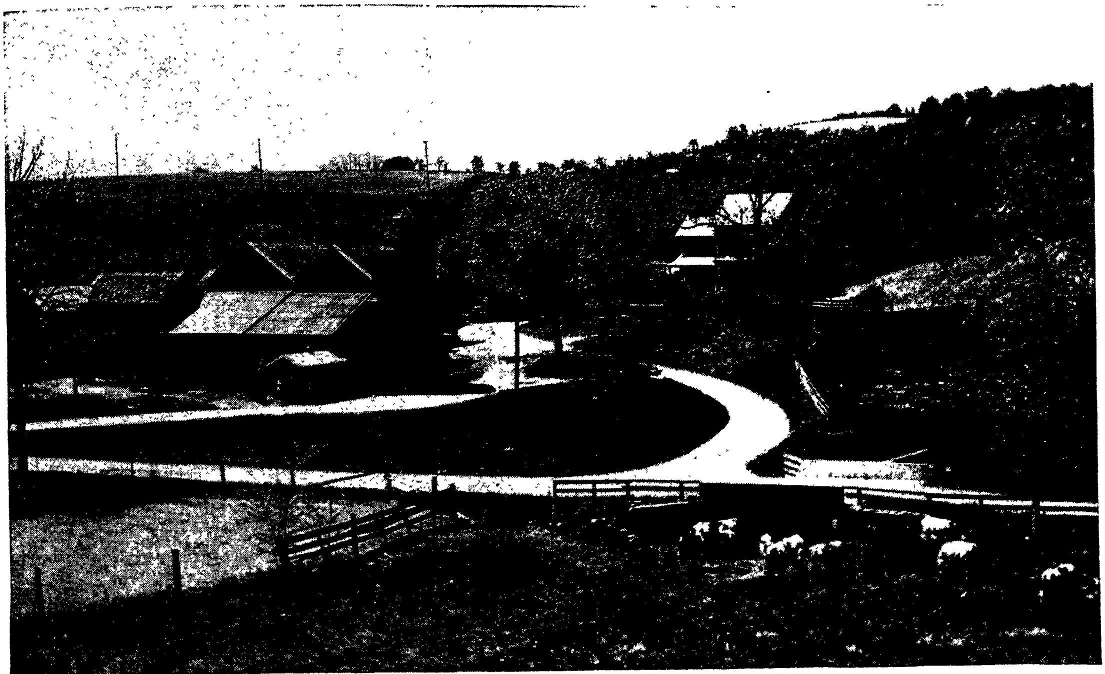

FIG. 109. A typical American farm in an excellent agricultural area in Hunterdon County, New Jersey. The principal income from this farm is obtained from the sale of milk from its herd of 40 Holstein cows; poultry and hogs provide additional income for the owner. Note the use of the silo for the storage of winter feed and the detached shed for handling milk and milk cans. (*Photograph courtesy of U.S. Department of Agriculture.*)

Seasonal Changes in North America. In humid continental regions much precipitation occurs at a time when temperatures are below freezing, and it usually takes the form of snow in the winter season. Hence winter snows often interfere with transportation, and the expression "snowbound" has great significance for residents of these latitudes. Snow remains on the ground for long periods in winter, forcing the people to store sufficient quantities of food and fuel to meet their needs during the long winter season. During that part of the year when the ground is snow-covered and frozen, erosion of the soil cannot occur—a condition not found in warmer climates. In spring, with the approach of warm weather, the snow melts, swelling the flow of streams and providing water for hydroelectric power and manufacturing in developed areas and transportation for the log drives that are an annual occurrence on many streams.

Human activities are governed largely by the marked seasonal changes. Upon the disappearance of the snow in spring, the soil thaws. Cultivation begins as soon as the ground is free from frost, and planting follows with the arrival of the first warm days. Fences must be straightened and repaired; stones are removed from the fields if necessary; the spring sowing begins in full force. Around the house, "storm windows" are removed and stored, and spring cleaning and painting are in progress. Winter stoves are dismantled and stored, and heavy winter clothing is placed in mothproof containers. As spring moves into midsummer and fields and woods change from brown to green, the time of greatest outdoor activity approaches. Daylight hours are longer, and time in the fields is spent in cultivation, planting, and other activities. Household activities include the canning and drying of fruit, to provide food supplies for the coming winter season.

Cattle are pastured in the open, and haying is in progress. Most farms carry on some slaughtering.

Upon the approach of autumn, the harvest season involves the cutting of cornstalks for fodder, the storage of hay for winter feeding, and the mowing, threshing, cleaning ("winnowing"), and sacking of grain. Food in quantities sufficient to meet the family needs must be stored—potatoes and other root crops in cool but frost-free cellars. House and barn are made secure against winter storms, and fuel must be provided for the long winter to follow. When snow isolates the farm unit, making it difficult to make long trips, the family becomes relatively immobile, remaining at home for long periods, especially while the cyclonic storms are in progress, snow is flying, and the wind is biting. Winter days are spent in tending stock, in watching that buildings are properly heated, and in household tasks that are best performed at this season.

Humid Continental Interior Regions of Eurasia. Temperature contrasts occurring with change of season are more pronounced in the interior of Asia than in the central part of North America; but, in spite of extremely low winter temperatures, the growing season is long enough for spring wheat to reach maturity and for the growing of rye, oats, and barley in some quantity. Root crops, as in North America, are staple foods, and the sugar beet is commonly grown to meet local needs. As in North America, the land is forested enough to provide a source of building material and fuel. Mid-latitude fruits, particularly apples, are grown. Farm animals are similar to those of our own North Central states—sheep, hogs, and cattle—and furs as a source of income are generally more important than in this country. The production of fibers, especially flax and hemp, is much greater than in the humid continental interiors of the western hemisphere.

Despite the general similarity of economic products, there is little else in common between the humid interiors of North America and Eurasia. Our farming is advanced, with much reliance upon mechanical equipment. The farms of the United States and Canada are individually owned and operated; for the most part they are profitable and productive. Those of Eurasia continue to suffer from inadequate equipment, poorly selected animal strains, and disease-ridden plants. Absentee farm ownership, formerly common; illiteracy; inadequate transportation facilities in Siberia; and other handicaps have prevented these lands from reaching their full measure of productivity. When completely developed, this part of the world should become an agricultural and industrial center of great importance, supporting many more millions of people than at present.

East-central Siberia experiences winter temperatures so low that the air can contain only extremely small amounts of water vapor; for this reason winters are very cold and at the same time dry. To the eastward, however, temperatures on the island of Hokkaido and the northern part of Honshu reflect the marine locations of those areas and provide otherwise subtropical and tropical Japan with a small extent of mid-latitude "continental" climate. Here the natives grow rye, oats, and barley as their staple grains. A hardy quick-growing variety of rice has been developed, but in general agriculture is backward and the extent of farm land is limited. Hokkaido, like New England, was a forested region, and it has supplied Japan with some of her needs for lumber, particularly softwoods. A little coal mining and much fishing are other human activities of importance on these remote northern islands. Many fishing boats, canneries, and other aspects of marine dependence are apparent along the coasts.

In Manchuria and other humid sections of north China the summers are too short for rice; it is replaced by wheat, barley, kaoliang (a grain sorghum), and millet as the principal native grains, though some corn introduced from America is also grown. Soybeans are important both for food and as a money crop. Livestock are kept in moderate numbers, com-

pared with those produced on American farm lands of equal area. Dependence on a vegetable diet allows more Chinese and Koreans to live on the land than would be possible if a dairying or stock-raising economy prevailed.

PROBLEMS

1. What are examples of the effect of rainfall upon the activities of farmers in your home locality?
2. What is the effect of heavy snowfall on transportation in most parts of the world? How is man overcoming these difficulties?
3. Why are the forests of humid continental interior regions of greater commercial value than those of the tropics?
4. San Francisco and St. Louis are located equally far north of the equator, but the January mean for San Francisco is 50° and that for St. Louis is 31°. Account for this marked difference in temperature.
5. What geographical significance does each expression have: growing season, silage, spring wheat.
6. Compare the character of soils in humid and arid climates of the mid-latitudes.
7. If farmers in Ohio tried to raise cotton, what conditions would they find favorable? What conditions would be unfavorable?
8. What natural conditions have encouraged the development of hydroelectric power in New England?
9. Portland, Oregon, and Portland, Maine, are nearly in the same latitude; will their climates therefore be similar? Explain your answer in some detail.
10. The greatest advances in the science of forecasting weather have taken place in the United States and in the European nations. How is this fact related to the following human activities in humid continental interior regions: agriculture, fishing, manufacturing, forestry.
11. Explain in detail the marked unreliability of weather found in humid continental interior regions.
12. How did the climate of New England differ from that of the England from which the Pilgrims and the Puritans came?
13. Name some valuable hardwoods that are obtained in the humid continental interior regions of North America.
14. Florida and California differ climatically, but both areas produce commercial supplies of citrus fruits. How do you explain this?
15. Why are the American people consuming about one-third less flour and corn meal per capita than in 1900?
16. The production of wheat has caused the following developments. In each case, name a special example of the development. (*a*) railroad building, (*b*) construction of irrigation works, (*c*) population movement, (*d*) port development.
17. Why do western Washington and Oregon receive more rain in winter than in summer?
18. Why doesn't southern California receive rain in summer?
19. Why are the forests of humid mid-latitude climates generally more valuable than those of the tropics?
20. Explain the erratic storms that occur most of the year throughout the greater part of continental North America.
21. Compare the cultivation of rice in Texas or California and in Japan.
22. Account for the greater density of farm population in rural China compared with a dairy region in the United States.
23. Give some valid reasons why the Japanese have migrated in relatively small numbers to Hokkaido.
24. Why does eastern Siberia experience colder winters than western Europe in the same latitudes?
25. What are the benefits and uses of snow?

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CHAPTER 10: *The High Latitudes*

The Subpolar Continental Climatic Type (Taiga)

North of the middle latitudes in the subpolar zone in the Northern Hemisphere a forested belt, predominantly of conifers, extends entirely around the world on the continents of North America, Europe, and Asia (Fig. 110). The northern coniferous forest, called *taiga* by the Russians, results from the climate that experiences extreme cold during its long winters and enjoys only a short cool summer (Fig. 111). Along the west coasts in subpolar latitudes, the winters are less severe and the growing season somewhat longer than farther inland, although the summers are even cooler because of the marine influence. The precipitation is heavier, with either an even distribution or a distinct winter maximum. Areas with this climate exist along or near the coasts of the Scandinavian peninsula, southern Chile, and southern Alaska.

In humid mid-latitudes the conifers are choked out by the broad-leaved species, and conditions in the interior are too dry for anything but grass; but in the taiga the conifers can survive tremendous ranges of temperature and a short growing season that would kill most hardwood trees. These forests are evergreen, but of needle species in place of the broad-leaved species of the selvas in the rainy tropics. The trees are of slow growth, since they have but a short growing period of from 1 to 3 months in length. Mixed with the conifers are some hardy deciduous trees, notably the birch, aspen, alder, and willow. Other hardwoods, such as beech and maple, may also occur mixed with the conifers along the southern edge of the taiga (Fig. 112). The coniferous trees of the taiga include only a few species of pines, firs, spruce, cedar, hemlock, and larch, in decided contrast to the numerous species that comprise the flora of the tropical rainy forests.

Climate of the Taiga. The greatest climatic extremes on the earth's surface are believed to occur in the taiga at Verkhoyansk in northeastern Siberia. The average range of the temperature totals 118°F. from a mean of −58°F. in January to 60°F. in July, with an extreme range of 187°F. from −93½°F. in February, 1892, to 93½°F. in July (Fig. 53). The Mackenzie Valley of Canada and the Yukon Valley of Alaska have summer temperatures exceeding 90°F. and winter temperatures that fall to −60°F. or −70°F., giving an annual extreme range of more than 150°. Because of the marine influence, the coniferous forest is found about 10° farther north on west coasts than on the east coasts of continents in the Northern Hemisphere. The taiga deteriorates northward, the trees becoming more and more stunted, as they do with elevation on a high mountain peak in lower latitudes, until finally the last spruce, birch, and willow disappear at the limit of tree growth and hardier plants like grass and herbs replace the forests. The last stunted trees may lack the height of a man yet have an age of one or two centuries. The total rainfall required for the growth of conifers need not be so great as farther south, because the rate of evaporation is low and the growing season is short. Most of the water from the snow of winter and the rain of summer remains available for use by trees.

Locally, in mountainous areas close to the ocean, very heavy snows may occur whose depth is measured in feet rather than inches. The great depth of snowfall in southeastern Alaska causes vast glaciers to form there that descend from mountains down to the sea in a cloudy stormy region having mean annual temperatures no colder than New England. In other places in the coniferous forest the

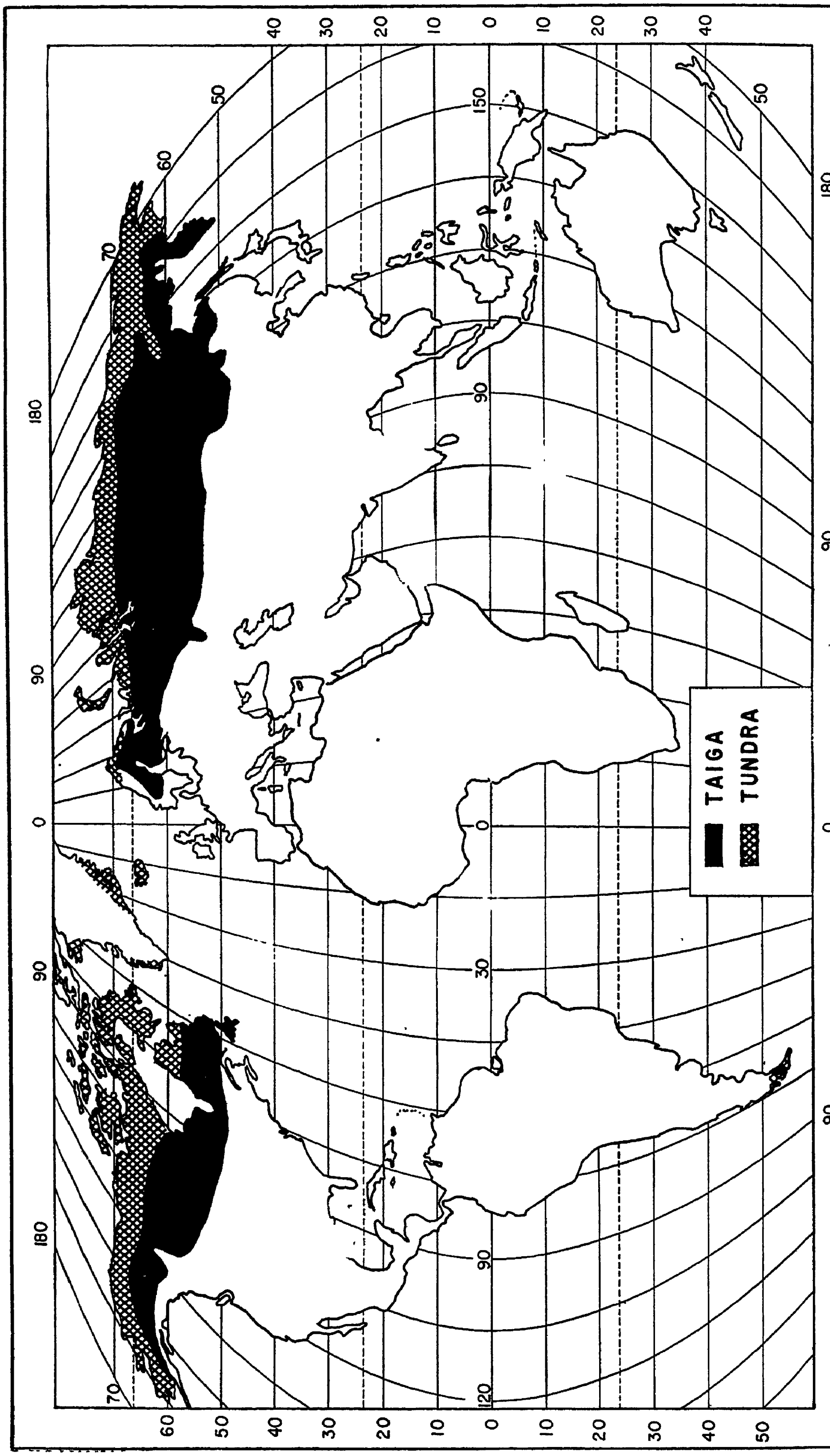

FIG. 110. The taiga and tundra regions.

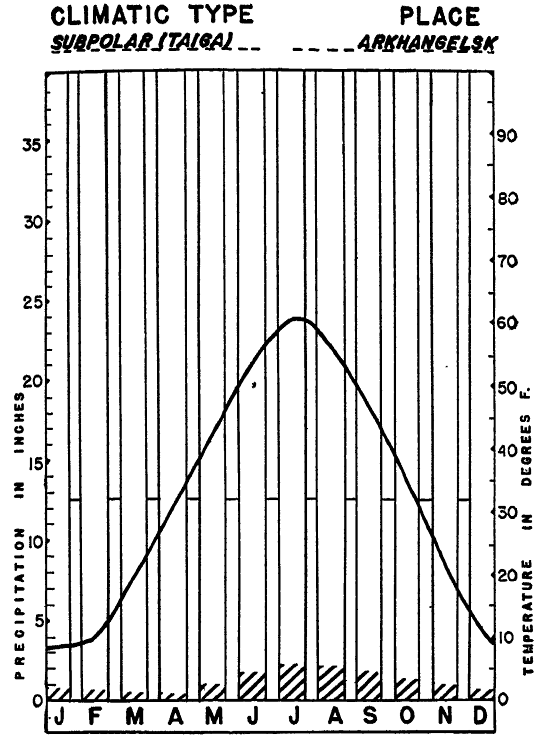

FIG. 111. Climatic graph for Arkhangelsk, U.S.S.R. The taiga lands in the Northern Hemisphere experience just enough warmth during the summer season to permit the growth of coniferous forests of large extent. Seasonal temperature ranges are great, but precipitation of rain and snow is relatively small. There is no marked dry season.

snowfall is only from one to a few feet in depth, but because of the cold the snow persists for many months.

In the northerly latitudes the forests have some advantages for travel during the cold of winter. The ground is frozen, and men travel freely everywhere on skis and snowshoes as well as using sleds pulled by dogs or reindeer. Except where the few railroads have been built, travel in summer is generally restricted to the waterways, which are numerous in the glaciated regions. Airplanes equipped with pontoons in summer and skis in winter are useful for speedy travel.

With the arrival of summer, the wild fowl migrate northward for nesting. Multitudes of wild flowers burst into bloom, trees put on new growth, and countless swarms of insects, especially mosquitoes, come into existence. Plant growth is very rapid because of the long hours of sunshine. Even wheat has matured in central Alaska, and hardier grains like oats and barley and root crops can regularly be grown there. Much of the taiga has been glaciated, and lakes, ponds, and swamps abound. Many animals like fish and waterfowl, and even larger creatures like moose, beaver, and muskrat get most of their food supply from the ponds and swamps.

Products of the Forests. The taiga supplies man with several valuable products; and, in spite of harsh conditions, people live in the forests in some numbers, although the density of population is low compared with that in more favored regions. Multitudes of fur-bearing animals are trapped during winter, and furs are exported to the industrial regions of the middle latitudes. These furs and other animal products are the most valuable commodity coming from large areas of the northern forests, and the lonely wilderness contains scattered trading posts at which the furs are collected from the natives. Areas with adequate rainfall and up to 3 months of growing season may supply commercial timber, but those with limited precipitation or shorter growing season have only a stunted growth of trees, of value only for local fuel and possibly for paper pulp.

The taiga supplies a large share of the construction softwood lumber cut in the world and most of the paper pulp. The best commercial stands of timber are located in the most favorable climate, along the west coasts and on the southern portion of the northern coniferous forests, where fortunately they are accessible to lumbermen. Timber is cut mainly during the winter in the commercial forests. Winter passes almost directly into summer, resulting in rapid melting of the snow and consequent flooding of the streams down which the logs, cut in the winter and piled along the stream banks, are carried to the pulp or paper mills. Most of the forested region has numerous streams down which the logs can be run and power sites to supply the

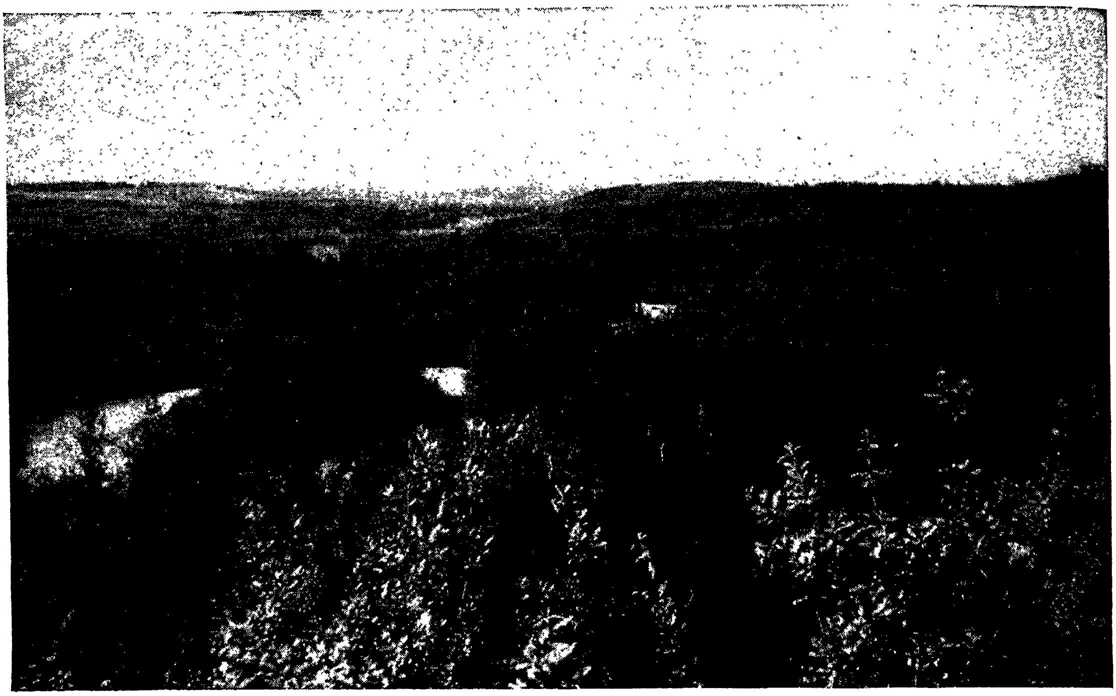

FIG. 112. Eagle River region northeast of Anchorage, Alaska, within the taiga zone. Note the lack of evidence of human occupation of this part of the continent. (*Photograph courtesy of the U.S. Department of the Interior.*)

needed energy for the mills. Frequently the sawmills and paper mills can be located on tidewater or convenient thereto, allowing cheap and easy transportation of the manufactured products to the markets of the world. In Finland, which is easily accessible to European markets, 45 per cent of all workers in industry are employed in woodworking establishments: sawmills, plywood factories, planing mills, and pulp and paper mills.

Fire is often a hazard in the taiga, because conifers during a period of drought become highly combustible, and once fire gets out of control in these forests it is hard to extinguish. Large areas of the taiga in both the Old and the New World have been burned over. Following the fires, birch, aspen, and other broadleaved trees form the beginnings of new forests. The conifers replace themselves very slowly; and, when a forest is once destroyed, a century or more may be required before it regains its old appearance.

Human Life in the Taiga. Much of the coniferous forest possesses only a poor leached soil, the so-called *podsol,* which develops under the climatic and vegetation conditions there existent. Field crops are limited to hardy grains like oats and barley for human use, and hay to supply the cattle. Nearly always dairy products form the chief item sold from the farms. Among the minor crops grown are potatoes, turnips, rutabagas and other root vegetables, peas, strawberries, and numerous other small fruits, and various leaf vegetables that can mature in the short summer with its long periods of sunshine that characterize the northern coniferous forests (Fig. 113). The value of a farm is generally based on the amount of hay that can be raised to supply the dairy cows and other livestock throughout the winter. Although millions of men live by agriculture in the taiga of Finland, Scandinavia, Soviet Russia, and Canada, the population is relatively small compared with that in more favored regions. Even trading towns are widely spaced. Because hard work supplies man with only the bare essentials of life and leaves little surplus for the luxuries,

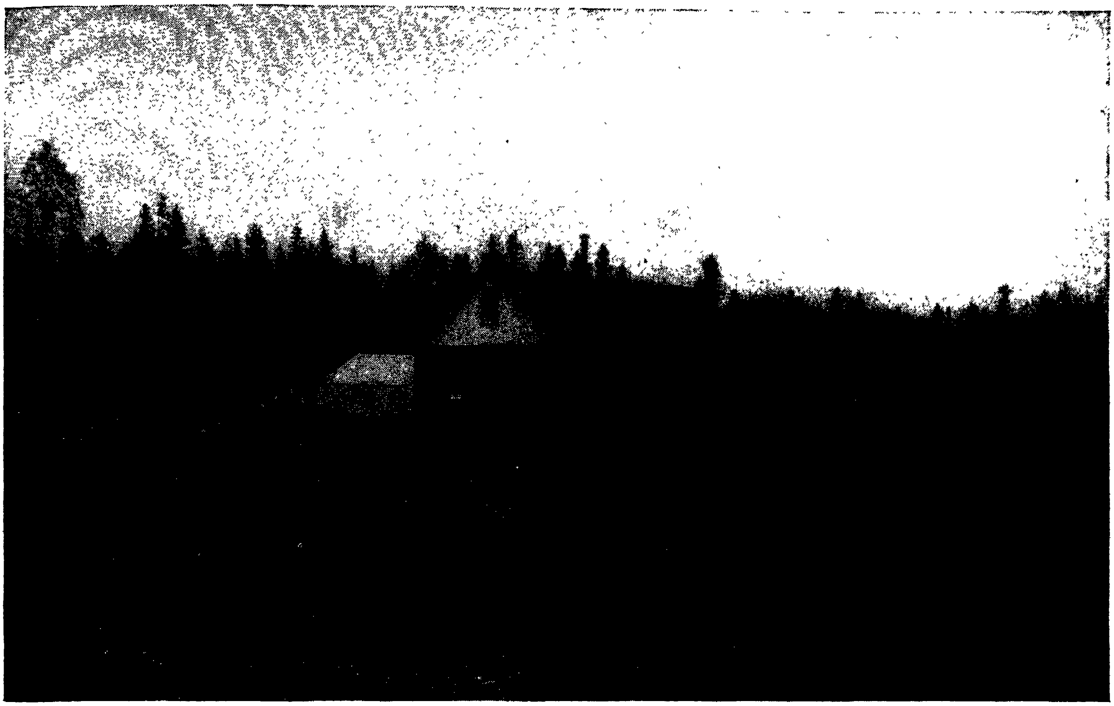

FIG. 113. Modern homestead in Alaska. The land has been cleared, and the forest itself has provided most of the materials from which the house was built. The cleared land has been planted in vegetables and grain. This type of human activity is relatively common on the northernmost frontier of the agricultural lands of the world.

the coniferous forests are unattractive to many. The population may be expected to increase slowly, but it seems unlikely that the northern forest will ever be extensively cleared and turned into productive farms.

The houses in the northern forests are usually of wood, with log huts the common home in the more remote places (Fig. 114). In communities with heavy snowfall, houses are often built with steep roofs from which the snow can slip more easily. Homes must be built to resist the cold, with walls that are thick and often hollow (air being a poor conductor of heat), double windows, and other insulation. Some food is secured by hunting large game animals like deer and moose that usually band together in "yards" during the snowy season and in deep snow have difficulty escaping from men on skis or snowshoes. Winter fishing may be done through holes cut in the ice.

In both northern Siberia and northern Canada, natives live in the coniferous forests, practicing no agriculture whatever. They find their full support from hunting, fishing, and trapping, securing their food, clothing, furs for trade, and material for tents from such sources. Trapping supplies them with some necessary material for garments that will resist the cold and also give them the furs which they can exchange at the trading posts for traps, imported foodstuffs, utensils, and other things they may desire. A trapper requires a large area for his string of traps, especially since the numbers of fur-bearing animals vary from year to year depending upon the food supply. In Canada the Chippewa Indians represent a type of the hunting forest tribe. In Siberia the Yakuts obtain their living similarly. The fur-trading posts, at which these natives deal with civilized man, may be scattered at distances of hundreds of miles, and in the forest wilderness they are generally built on the most accessible locations on the

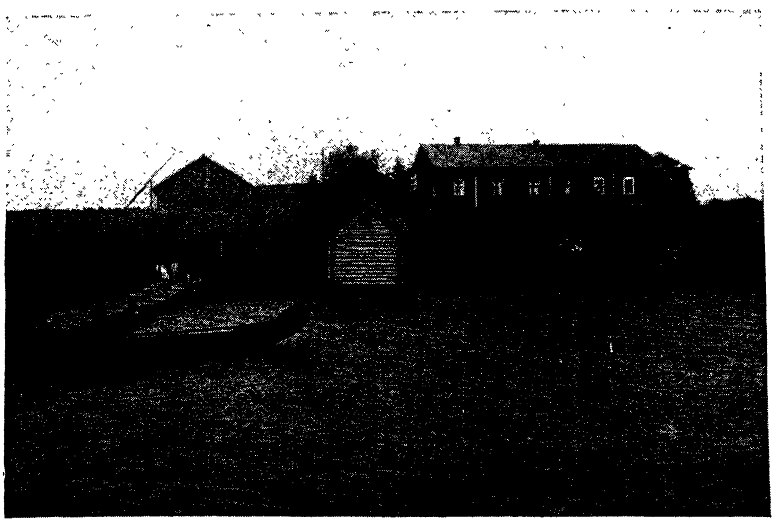

FIG. 114. Finnish farm and farmhouse, typically located where water transportation is available during the summer. The small structure on the shore is the usual shelter for the steam bathing so popular among these people. (*Photograph courtesy of Eugene Van Cleef.*)

FIG. 115. Mining community of Yellowknife, Northwest Territories, in northern Canada. Yellowknife is reached more easily by airplane than by other methods of transportation. Note the comparatively barren glaciated landscape and the use of water transport indicated by the small boats in the foreground. (*Photograph by the Department of Mines and Resources, Bureau of the Northwest Territories and Yukon Affairs, Dominion of Canada.*)

ocean or inland waterways from which natural routes diverge.

Modern Development. Mining may lead to a large influx of population to the limited areas where ores occur (Fig. 115). The Laurentian Upland, between the Great Lakes and Hudson Bay in Canada, is an important mining area in which mineral deposits have been discovered even beyond the Arctic Circle. The southern portion of the Laurentian Upland is served by railroads; but to reach the "far north" formerly took many weeks of continuous travel by steamboat and canoe, and except for dog sleds the remote mines and fur-trading posts were completely shut in during the winter. Now prospectors, mining engineers, and fur buyers fly to their stations, going by airplane in a single day over the forest wilderness that formerly would have required a month or more of travel. The airplanes are generally equipped with pontoons for landing on the numerous lakes in summer, and in winter skis are substituted for the pontoons. Other mining regions are located in the taiga of Siberia, Russia, and Scandinavia. Mining development of course leads to only temporary occupance of forest land; and when the mines are worked out, the remote mining settlements will be abandoned.

The Tundra

The Tundra Environment. The word *tundra* suggests a frozen, snow-covered, treeless waste in winter, and even in summer it shows only scanty stunted vegetation. Unattractive as such a land sounds, with nearly 9 months of winter, 2 of summer, and about 2 weeks each for spring and autumn, people live on the tundra in apparent health and happiness. Seasons in these regions could as well be divided by light and darkness as by cold and warmth, since the presence or absence of the sun is the most important thing. Near the Arctic Circle several weeks of winter have hardly any sunshine at all, while in the summer almost continuous sunshine lasts for a similar period during which the sun hardly sinks below the horizon.

Polar climates generally are marked by temperature averages under 50°F. for the warmest month (Fig. 116). A little vegetation can exist when the warmest month has a temperature higher than 40°F., but when the average for this month falls to freezing, only a polar desert, like most of Greenland, can exist. This is an extreme polar climate. Winter temperatures in polar regions are low but seldom reach the excessively low temperatures of continental interior regions, as at Verkhoyansk in the boreal forest. The winter is notable for its extreme length. Snowfall is light, but strong winds cause drifting and the snowdrifts often last into June before they melt. As the length of day increases, winter suddenly disappears and summer comes to the tundra almost overnight. Flowers blossom; small berries mature; ducks, geese, and other waterfowl migrate and nest along the waterways and ponds; and mosquitoes, flies, butterflies, and other insects fill the air. In most of the tundra the ground thaws out only on the surface and remains permanently frozen underneath, causing the land to be poorly drained and producing in many places a spongy swamp, or *muskeg,* where ideal conditions exist for the breeding of mosquitoes (Fig. 117). During the short summer, the inhabitants prepare for the long winter. By the end of August ice forms on the tundra ponds at night, and the first swirls of winter snow follow shortly. Trading ships hurry away to avoid being frozen into the floes for the winter. The length of day rapidly decreases, and the long winter is again at hand.

The Reindeer and Tundra Life. In the Old World, in northern Scandinavia, Russia, and Siberia, live natives whose main support and livelihood is reindeer. These domestic animals, closely related to the caribou of North America, thrive under conditions that would quickly bring death to most other ani-

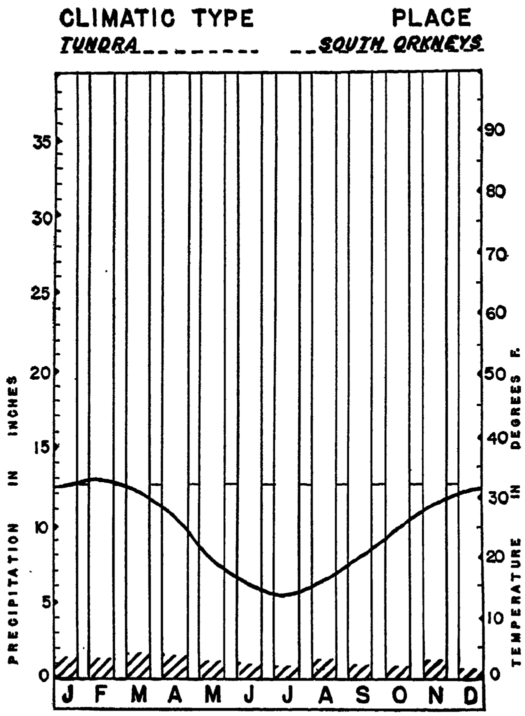

FIG. 116. Climatic graph for South Orkneys. The high-latitude tundra lands experience very low temperatures throughout the year with most months having means lower than freezing. These temperatures are too low to permit the growth of trees. Precipitation occurs largely in the form of snow, but the total amount each season is small because the air is too cold to contain much moisture.

mals. Underneath the skin and hair, a caribou or reindeer is protected by a layer of fat so that severe cold and biting winds do not bother the creature. It has broad cloven hoofs, useful for travel over the snow and for pawing away the snow to secure the reindeer moss and other feed upon which it depends. In fact, reindeer generally keep in better condition through the cold winter than in summer, when numerous biting insects make their lives so miserable that they can hardly graze in comfort.

The Laplander and the Siberian tundra tribes secure shelter, raiment, and food from the herds of reindeer. Some reindeer are taught to draw sleds over the snow in winter, but as a rule they are not used for beasts of burden. Reindeer does may be milked. The animals not only supply ordinary meat but their internal organs furnish vitamins which in our latitudes would be obtained from vegetables or fruits. Reindeer hide supplies the material for much of the clothing of the natives and the tents in which they live. Unless their lives have been modified by contact with higher cultures, the natives who keep reindeer are nomads and must move with their herds as required by conditions of feeding. Once the reindeer moss and other herbage has been thoroughly grazed, it may require 2 or 3 years before it recovers sufficiently to be grazed again. A herd of reindeer must have a very large grazing area, and it is not uncommon for the animals to roam from 20 to 30 miles a day in search of feed. Naturally the population of the tundra where the natives live with their herds is scanty. Nevertheless the numbers of people are greater and life is safer than in northern regions where reindeer do not exist.

The Laplanders in northern Norway (Fig. 118), Sweden, and Finland have a much higher cultural development than the natives of northern Siberia or the Eskimos and Indians of polar North America. Laplanders migrate to the tundras in summer and back to the forests of the taiga in winter, but some of them occupy semipermanent homes in winter (Fig. 119). There are also permanent schools in the forests, attended by the children during the winter season. The Chukchi, a less advanced reindeer-breeding tribe of northern Siberia across Bering Sea from Alaska, use reindeer to supply almost their entire needs. The Chukchi live on the cold tundra and have a limited number of scrub willows, alders, and larch, but reindeer moss and other lichens furnish abundant food supply for the reindeer. The Chukchi tribe wanders with its reindeer herds over a range of thousands of square miles, the winter being spent where timber provides some shelter and the summer on the tundras which are relatively free from insect pests. A single native may own many hundreds of animals. Reindeer are slaughtered when they are needed for food, espe-

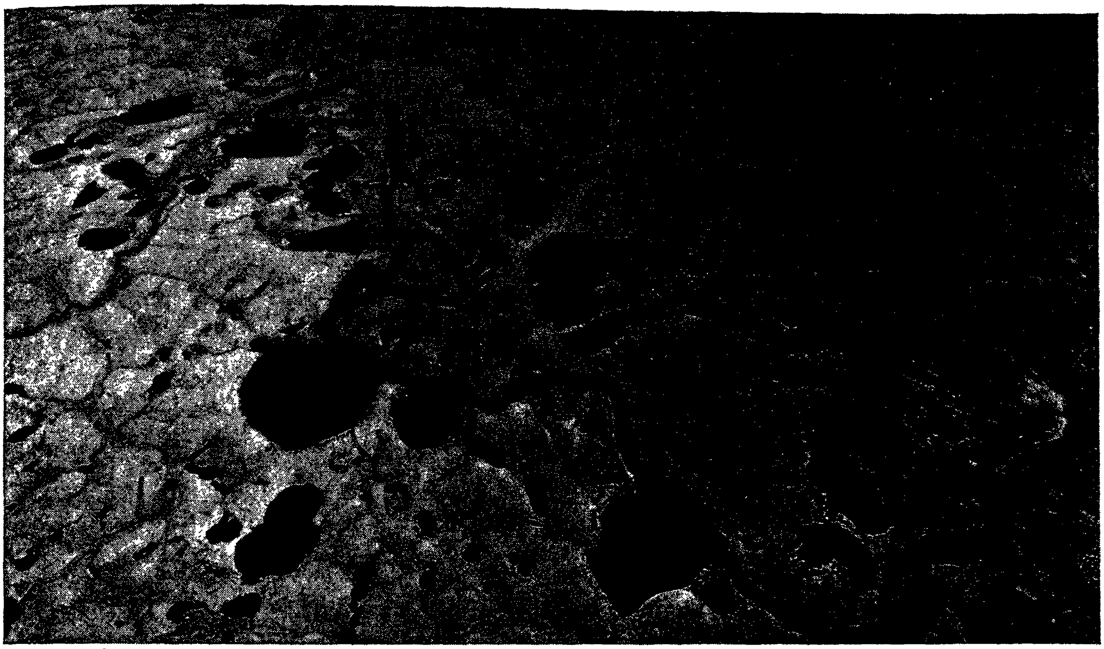

FIG. 117. Tundra landscape of the Yukon-Kuskokwim delta, western Alaska. Only scrub vegetation can live on these frozen muskeg plains. (*Air Force photograph.*)

FIG. 118. The Lapps occupy tents during the brief summer of northern latitudes, because their dwellings must be readily portable to conform with their nomadic life. This Lapp tent is made of birch poles covered with canvas or sacking. (*Photograph courtesy of Eugene Van Cleef.*)

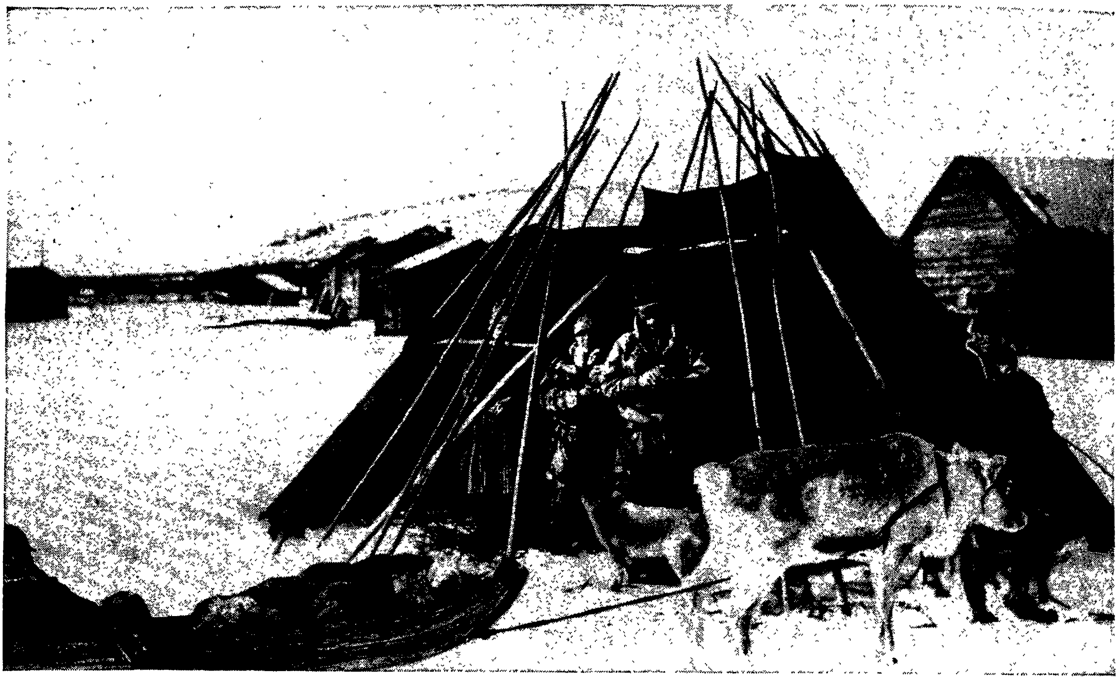

FIG. 119. Lapp nomads of northernmost Sweden and Finland depend on the reindeer for their subsistence. Many of their shelters must be temporary by necessity although their permanent dwellings may take the form of those shown in the background. (*Photograph courtesy of Eugene Van Cleef.*)

cially in the autumn when their coats are in best condition for making needed clothing supplies. A few roots and wild berries may be gathered, but the principal food is reindeer meat.

In Alaska and northern Canada, the caribou once existed in herds of many millions and supplied food to both northern Indians and Eskimos. The caribou is really a wild reindeer that is somewhat larger than the domestic variety; the latter was once limited in its range to northern Eurasia. Caribou and reindeer can be interbred. By the introduction of high-powered rifles, the numbers of game animals were much lessened and in places the game was nearly exterminated, causing natives to perish occasionally from starvation. To help this situation, reindeer were brought to Alaska (Fig. 120) and more recently to Canada; today the living conditions of Indians and Eskimos who depend on these animals have improved materially. Even an export trade in reindeer meat has been under experimentation, with shipments sent out from Nome, Alaska.

The Indians of Tierra del Fuego. Toward the southern tip of South America is found an environment that is quite unattractive to civilized people. The climate is very stormy, rainy, and cold. Dense forests clothe the lower parts of the mountains, which descend abruptly into the sea, and snow and ice cover the upper mountains most of the year. Occasional glaciers descend entirely to sea level, furnishing conditions resembling those along the Gulf of Alaska. The Indians here never practiced agriculture and had no permanent homes. Each family used a boat to carry its members and their few possessions from place to place along the shore in search of food. The Onas and Yahgans living on Tierra del Fuego and the maze of other nearby islands wander along the shores, fiords, and islands and camp wherever shellfish (their staff of life) or other food might be available. Although these natives are rather a hardy race,

FIG. 120. Herd of reindeer in a corral near Nome, Alaska. *(Photograph courtesy of the U.S. Department of the Interior.)*

they have never advanced beyond a very low cultural level because of the harsh and repressive environment. White miners, traders, and trappers have entered the region, but few care to bring their families and make permanent homes or remain long in a place that is so windy, cloudy, and rainy.

Few primitive peoples can withstand the diseases and changes of food, clothes, and living conditions that follow contact with the white man. Most of the native people in the southern end of America have sadly declined in numbers, and some tribes have become entirely extinct. Europeans find the region so unattractive that the white population is very small.

The Eskimo. The Eskimo secures his living in one of the most formidable natural regions on earth, along the coasts of Greenland and the Arctic Ocean. No agriculture is possible, and almost no vegetable food is available. In some places on the land, caribou and musk ox can be killed for food, but in others they are absent. Of necessity most of the Eskimo food supply comes from the sea. Fortunately northern waters swarm with *plankton* (floating organisms) and other small forms of life on which fish, seal, walrus, and whales thrive. The seal serves as the staff of life to the Eskimo as the reindeer does for the Laplander or the buffalo did for the Sioux. Sometimes many seals are secured at one time, especially during the breeding season; but at other times, especially in winter, the animals must be hunted one by one, being secured by patiently waiting for hours on the ice at a breathing hole of the seal where the creature is speared when it appears. The thick layer of blubber that keeps the seal warm in winter supplies the Eskimo with food as a substitute for the starchy foods of warmer climates, and he also finds use for it for light and heat in his home. Walrus, polar bears, and whales are also taken. The general health of the Eskimo was better in their uncivilized condition than after they secured white man's flour and other imported foods. The arctic fox, ermine, and hare supply furs for clothing. Animal skins are both warmer and more waterproof than woven fabrics. Even white men traveling in the arctic wear the Eskimo's skin boots, furry trousers, and windproof coats and parkas.

The Eskimo in summer lives in a skin tent and in winter in a conical stone and sod house often built over a pit dug in the ground. When covered with snow, an Eskimo village is almost invisible. On hunting trips they build temporary hemispherical huts, called *igloos,*

out of snow blocks. Eskimos have one domestic animal, the dog, used for pulling the sleds in winter and to help in hunting—especially the polar bear. Originally all the utensils of the Eskimo were made of stone, bone, sinew, skins, and driftwood from the native environment. To an extraordinary degree the Eskimo shows how man can overcome the handicaps of a poor and harsh environment by learning how to utilize fully the available food supply and raw materials.

Boreal Climates and Peoples in Mid-latitudes. Boreal conditions can result from high altitude as well as high latitude. Thus the Plateau of Tibet adjoins tropical India on the north but is an entirely different world. Although the plateau is high, it is lower than the Himalaya Mountains, which shut off most of the monsoon rains from the south. The winters are long and severely cold. Because of the altitude and position in the interior of the continent, Tibet and some other highlands in central Asia are cold deserts. Only animals especially adapted to the conditions can survive. In some of the interior deserts horses, mules, and Bactrian camels serve to bear burdens, but in the highest and generally coldest localities the yak is the only burden bearer able to endure the harsh conditions. Naturally the population is very scanty and widely distributed. A few of the people practice primitive agriculture in protected localities during the short summer where irrigation water is available. More of the natives are semiroving stockmen or complete nomads; in either case they depend entirely upon their herds for a livelihood.

Civilization in this cold desert environment can never reach the heights attained in more favored localities. Some of the more ambitious and energetic people leave and seek homes in better environments. The inhabitants who remain must be contented with a meager diet and other poor conditions of life. Most of their time is taken up in securing the essentials for existence, and they have little time for leisure to develop the arts and literature (Fig. 121). Fuel is lacking, and the dried manure of animals must serve for cooking fires. Since the houses can be warmed little with this fuel, the natives dress in quilted garments, furs, and skins to keep warm. In Tibet nearly one-third of the inhabitants live in monasteries or nunneries and have not

Fig. 121. Group of Kirghiz women living in the central part of Asia in the Russian Pamirs. Their dwelling, a yurt, appears at the left. They must wear heavy padded clothing in order to be comfortable in the continental climate which prevails in these mountains. (*Photograph courtesy of the American Museum of Natural History, New York.*)

married. This custom helps keep the natural rate of increase in population low and makes it possible for the food supply to support the population, which remains nearly stationary. If the number of inhabitants increased rapidly, there would hardly be food enough to go around. Although the temperature on a cold desert is quite different from that on a hot desert, people nevertheless live under somewhat the same conditions. In both cases the natives are largely nomadic and are supported on the products of their herds. The regular food consists of milk, curds, or a sort of cheese, with meat being consumed only when available.

Polar Ice Caps. The most forbidding and useless boreal climate is that of the ice caps. Here the mean temperature of no month averages above 32°F. and snowstorms may occur at any time of year. Only during a short period of the year when the sun shines constantly does the air temperature rise high enough to thaw some of the snow on top of the glacial ice. Temporary pools and streams of water may then exist. No large plants or animals and of course no human beings live permanently on the ice caps, which are therefore more complete deserts than those of tropical location. Antarctica and all of Greenland except narrow coastal strips are covered with an ice cap. Smaller caps are found in Iceland, Svalbard, South Georgia, and other polar islands. Some high mountains in lower latitudes also support permanent sheets of ice in southern Alaska, Canada, Scandinavia, and Tierra del Fuego.

Air aloft over the ice cap is chilled by the ice and thereby becomes denser; a high-pressure area (anticyclone) is built up. From this polar anticyclone cold masses of air slip off toward lower latitudes, and many believe that the whirling storms called cyclones, characteristic of mid-latitudes, are created when these cold air masses come in contact with masses of warm tropical air.

The two large polar ice caps cover high

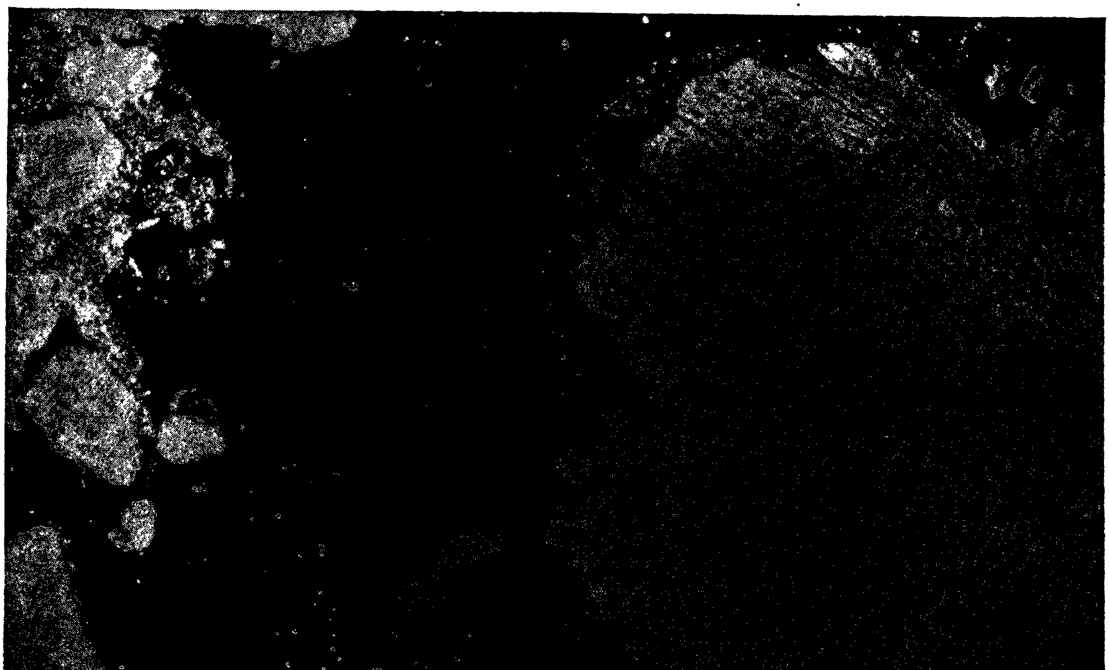

FIG. 122. The snout-like end of a glacier appears at the right, and the glacier has spawned many small ice floes and snowbergs. A larger glacier would break up into icebergs as it entered the sea. (*Air Force photograph taken near Bache Peninsula on Ellesmere Island, Baffinland.*)

plateaus, possibly of a basin shape with ridges toward the plateau edge that help retain the ice sheets. Lowlands in the arctic do not receive enough snow for the development of glaciers, but plateaus and mountains can possess them. Of course the snow and ice line is much lower in Greenland than in mid-latitude and tropical regions, but it reaches sea level only at certain bays in which the glacial ice descends valleys from the interior and breaks off to form icebergs (Fig. 122). In summer the Labrador Current brings these icebergs southward until they melt in the Atlantic waters. An international ice patrol, to which the United States belongs, guards the steamer lanes and warns shipping by radio of the location of floating ice so that disasters like that of the *Titanic,* sunk in 1912 by collision with an iceberg with a loss of 1,500 people, can be avoided. No large ship has collided with an iceberg since the patrol was started. The use of radar equipment further increases the protection against serious damage to shipping by these dangerous ice masses.

Problems

1. What is the effect of the short growing season on farming practices and the type of crops of the Matanuska Valley, Alaska?
2. How is it possible to mature wheat in most years well north of Edmonton, Alberta?
3. Why is it difficult to ship wheat to Europe from Churchill on Hudson Bay, even though a railroad has been built to this point from the wheat-growing prairie provinces of Canada?
4. What is nature's controlling factor with regard to plant life in high latitudes?
5. Why has the taiga scanty rainfall?
6. Why, in spite of little precipitation, do trees grow in the taiga?
7. Prepare a paper, not exceeding one page in length, on any one of the following topics: (*a*) commercial production of reindeer on the Seward Peninsula, (*b*) the decline of whaling in the arctic regions, (*c*) fur sealing on the Pribilof Islands, (*d*) problems of the migratory Lapp reindeer herders, (*e*) arctic Canada as a source of fox pelts.

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CHAPTER 11: *Forests and Forestry*

Man's Relation to Forests. Many men depend upon forests for their occupations. At first primitive men hunted wild animals and gathered roots and berries provided by nature in the woods. A few small groups of men, like the Pygmies of the Ituri Forest in the Belgian Congo, the Negritos in remote forested mountains of Luzon, and Pygmies in interior New Guinea, still obtain their living in this primitive manner. More advanced peoples made clearings in the forests for planting crops, and their hunting was supplemented by agriculture. The American Indians, for example, raised corn beneath the whitened dead trees killed by girdling in the forests of the eastern half of the United States. Sometimes animals were domesticated and a combination of livestock raising and subsistence farming was carried on, as in ancient Germany and Gaul, or today in parts of the Balkan Peninsula.

When commerce develops, different natural forest products are gathered to exchange for the manufactured goods and luxuries craved by the forest men. Among these products are rubber, palm oil, Brazil nuts, ivory, and dyewoods of the tropical forest. Honey, wax, resins, turpentine, furs, perfumes, leathers, drugs, and raw materials for varnish and tanning are other products gathered from forested lands and entering the world's commerce.

Forest Industries. Often the residents of forests have gained skill by long practice in the carving of wood and the fabrication of articles made of wood. They produce for export quantities of wooden toys, wooden bowls, spoons and other kitchenware, barrels, boxboards, shingles, wooden clocks (now more often made of metal), furniture, and the like. Sometimes special home industries are started in which skilled labor rather than expensive raw materials is the essential consideration. The making of lace by hand, the raising of canary birds in the Harz Mountains of Germany; the fox fur farms in lands of cold winters, and the manufacture of watches and other types of metalwares requiring little material constitute a few examples of the principle.

Animals in the Forest Economy. The pasturage of livestock is one of the common industries of a forest region, and, as a rule, the forests supply some fodder and browse for cattle and other domestic animals. Milch cows and beeves are the most common domestic animals grazed in forest regions. In general, sheep fare better on open plains, although these animals are often pastured in summer on meadows within mountain forests and on pastures above the timber line. Goats are kept more commonly in the hill regions of brush and open woods, like those of the Mediterranean climate, since they are good rustlers and seem to thrive on feed too poor for cattle and horses. Swine utilize acorns and beechnuts in the Balkan forests and grub for roots and other food in the woods of the southern United States, but in most parts of the world pigs are not allowed to roam freely. A lack of concentrated feed, in combination with the poor roads usually found in forests, causes oxen to be preferred over horses for draft purposes in "backwoods" parts of southeastern Europe in the Balkans and Carpathian Mountains.

In New England and the hilly parts of New York and Pennsylvania, still largely wooded, dairying is a chief industry on the cleared land, because these sections are well served by rail and highway and the shipment of perishable products is possible to the cities of Boston, New York, or Philadelphia. Regions less favored by swift transport may be forced to turn their surplus milk into butter or cheese or to preserve the milk by manufacturing a condensed or powdered product. The Pacific Northwest and the St. Lawrence

Valley, as well as the Dominion of New Zealand, are examples of places where processing of milk is a common practice.

Forests as Barriers. Forests usually handicap travel and may provide serious barriers to human movement and communication; in this way the wooded lands may be compared with more obvious barriers such as mountains or deserts. Most mountains support forests, in fact, and difficulties of travel may come from the combination of trees, rocks, and steep slopes. In Germany the same word, *Wald,* is used for forests and mountains. The Black Forest and the Bohemian Forest, for example, are understood to be mountains as well as forests.

Since communication is slow and the soils are generally poor except in the narrow valleys, the people of the forests are isolated, and regional population density is low. As a result, their customs and culture change slowly compared with those of cities and fertile well-developed and populous lands. Woods people, however, usually have estimable qualities and are typically friendly, hospitable, hardy, and hard working.

Sometimes men from surrounding plains flee to the forests for refuge after committing offenses against the laws. The Slavs in Russia fled to the forests to escape the Mongol horsemen of Genghis Khan and gain protection against invaders of their land.

The larger clearings in the forests tend to become the sites of local governments. In the days of poor transportation and isolation, these places often achieved complete independence. The forested mountains of southern Germany during the Middle Ages had hundreds of small but independent or semifree principalities, kingdoms, dukedoms, electorships, and other titles. Not until modern transportation developed did the multiplicity of governmental units disappear.

Recreation. Forests are favorite places for recreation. In the United States as many as 18 million people have used 152 national forests for hunting, fishing, camping, winter sports, hiking, riding, and picnicking. Another 37 million people drove through the national forests on highways provided by the government within their boundaries. The pleasant shade and higher humidity of wooded regions are especially appreciated during hot spells of weather. Nearly every state in the Union has systems of wooded parks for use by its citizens and visitors, and many cities like Chicago, Cleveland, and Akron maintain extensive park tracts for the enjoyment of their residents.

Large trees are an interesting attraction for many people and when left standing in parks may bring in more revenue from tourists than they would have brought if they had been cut down and used for lumber. The Sequoia National Park, the forests of redwoods in California, and the Olympic National Park in Washington, with its giant fir, spruce, and cedar trees, attract thousands of tourists each year. The display of rhododendrons in the Great Smoky Mountains National Park is of interest to many visitors each year.

Forests of the United States

About 624 million acres, or one-third of the total land area of the United States, are now called forest land as compared with the original stand estimated to have covered 820 million acres. It is believed that 461 million acres are capable of producing timber of commercial quality either now or in the future under proper management. The remaining 163 million acres are "noncommercial" forest land: mountaintops, desert fringes, chaparral and other scrub forests, mostly in the West and withdrawn for parks and other purposes. Of the commercial forest land, about 205 million acres contain saw timber. Of this area, about one-fifth supports virgin timber and four-fifths is forested with second growth. Cordwood areas total 95 million acres. About 86 million acres are in satisfactory stand of seed-

lings and saplings, but 75 million acres, or one-sixth of the whole, have only poor stands of seedlings and saplings or are nonrestocking. Within all the above classifications, there is a total of 164 million acres of poorly stocked or denuded forest land. Any forest plan for the United States must consider the restocking of this unproductive land.

The total stand of saw timber in the United States is estimated to amount to about 1,750 billion board feet. (This unit is 1 foot square and 1 inch thick.) *Saw timber* includes marketable trees large enough to yield logs for lumber. The term *all timber* includes trees 5 inches and larger in diameter at heart height. Thirty-one per cent of the standing timber of the United States is located in the Pacific Northwest, 28 per cent in the southern states, 10 per cent in California, 21 per cent in the northeastern and north central states, and 10 per cent in the Rocky Mountain regions. The region having a mid-latitude west-coast marine climate occupies only 6 per cent of the entire forested area of the United States but contains almost a third of the remaining saw timber, a situation brought about because of the dense stands of large trees in this part of the country.

Of the commercial forest land in the United States, 345 million acres (75 per cent) are privately owned, while 116 million acres (25 per cent) are in public ownership. The commercial forests in private ownership contain nearly three-fifths of the standing saw timber. Large expanses of publicly owned saw timber are inaccessible and of little commercial use at present. They do protect mountain watersheds against excessive erosion, however. As roads are built into them, careful logging will utilize much of the mature saw timber that is now out of reach. The largest block of publicly owned commercial forest land, 73 million acres, is included in the national forests, supervised by the U.S. Forest Service of the Department of Agriculture (Fig. 123). Some 43 million acres lie within Indian reservations, state forests, and other publicly owned commercial forests. Three-fourths of the publicly owned forests are in western states. Farm wood lots account for 139 million acres of timber, owned by 3,200,000 farmers. Any comprehensive plan for forest betterment should extend good forestry practices to these wooded areas, which are small on any one farm but large in total acreage. More than half of the farm wood lots are used for pasture, and this interferes with their proper reproduction of first-class timber.

Of the total commercial forest areas of the United States, the South has the highest acreage, 39.8 per cent, partly because the climate of that section favors the rapid growth of trees. The northeastern and middle Atlantic states have 15.7 per cent of the forest acreage; the three lake states (Michigan, Wisconsin, and Minnesota) 11 per cent; and the central states (Ohio, Indiana, Kentucky, Illinois, Iowa, and Missouri), 9.6 per cent. In the central states, the forest land is small in extent because geographical conditions favored the use of the land for agriculture, and most of the remaining timbered areas are in farm wood lots. The southern Rockies have 3.4 per cent; northern Rockies, 6.3 per cent; California, 3.5 per cent; and the Pacific Northwest, 10 per cent of the forest lands.

Expressed in terms of volume—that is, board feet—the western softwoods aggregate 1,037 billion board feet of saw timber, 64 per cent of the total for the country. Other totals in volume of saw timber are southern yellow pine, 11 per cent; northeastern and lake softwoods, 4 per cent; and hardwoods east of the Great Plains, 18 per cent. The Douglas fir of the Pacific Northwest represents 27 per cent of the volume of the nation's saw timber, and ponderosa, or western yellow pine (Fig. 124), 11.5 per cent. It will be seen from the above figures that the volume of saw timber and the acreage of the forests of a given region vary widely in different sections of the United States.

The peak years for lumber sawed in the United States were 46 billion board feet in both 1906 and 1907, and 44½ billion in both 1909 and 1910. Production of lumber de-

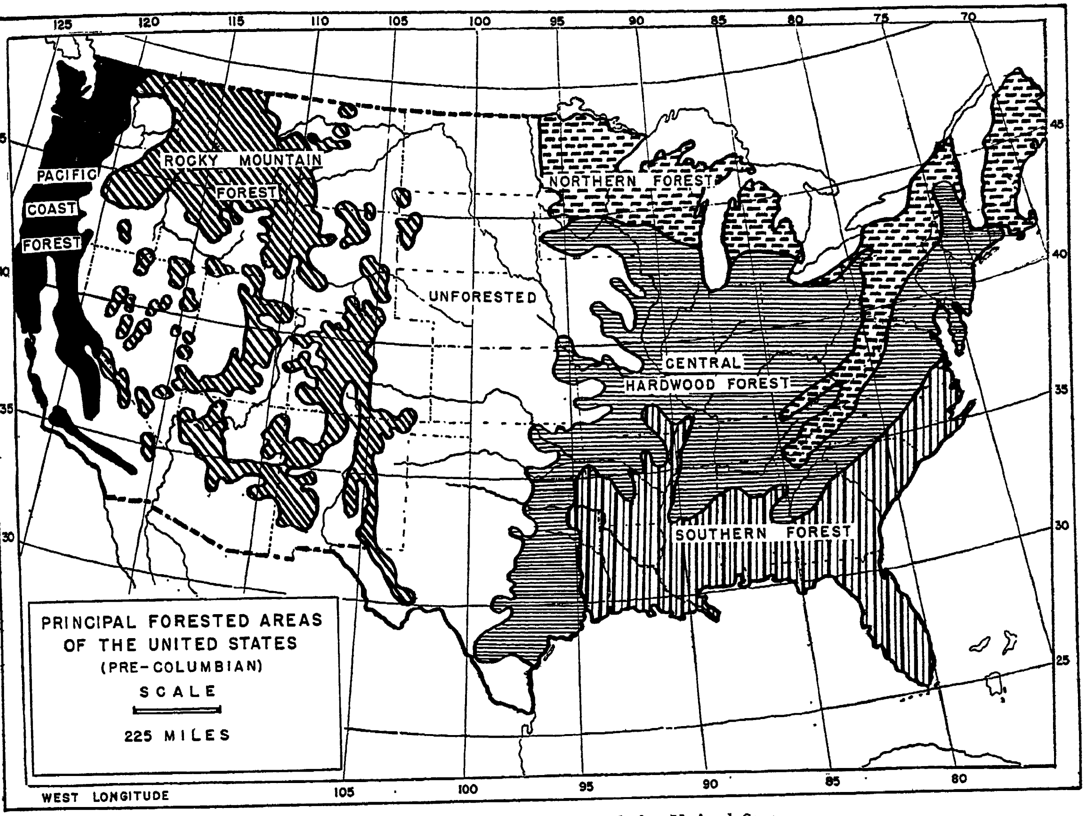

FIG. 125. Principal forested areas of the United States.

are well managed, this section, which has much nonagricultural land, has favorable conditions for tree growth, and is close to market, should serve as one of the great permanent forest areas of the United States.

Central Hardwoods. This region, the largest of the forest regions, includes the piedmont area east of the Appalachian Mountains and the interior region west of those mountains, extending across Ohio and the southern Great Lakes section to the treeless prairies of Iowa, south into northern Alabama, and southwest through Missouri and eastern Oklahoma into Texas. The forest here consisted of mixed hardwoods of great commercial value, including oaks, ash, elm, cherry, beech, maple, walnut, poplar, basswood, and hickory, with minor quantities of pine and hemlock. Trees in the southern portion of the central hardwoods include white oak and other oaks, red and black gums, ash, hickories, elm, sycamore, poplar, walnut, red cedar, buckeye, maple, and Osage orange. The hardwoods in Illinois and Iowa were largely restricted to the bottom lands along the streams, with the uplands of the interstream spaces being chiefly covered with tall prairie grasses. Much of the hardwood forest has been cleared from the fertile plains and rolling hills, to be replaced by productive farms, many of which still maintain some acreage in wood lots, which supply three-fourths of the timber acreage in the regions. The largest forest stands are in hilly sections of southern Ohio, Indiana, and Illinois, the Highland Rim in Kentucky and Tennessee, and the Ozark Plateau of Missouri and Arkansas. The hardwoods were valuable for the manufacture of furniture, interior finishing, wagons, and many other items.

Southern Forest Region. Extending from southeast Virginia to eastern Texas and including all the Atlantic and Gulf Coastal plains westward into eastern Oklahoma and eastern Texas, Florida except for the southern tip, and the Mississippi Valley into southeast Missouri, this region is characterized by pine forests that cover the hills and broad plains and associated alluvial flood plains and swamps. The forest trees on the sandy plains consist of different types of southern yellow pines, including longleaf, slash, and loblolly pine, with cypress, tupelo, red gum, oak, sycamore, cottonwood, elm, and other trees along the moist river bottoms. Inland as the elevation mounts toward the Piedmont Plateau, the trees consist mainly of mixed hardwood forest, with shortleaf and other pines. The red or sweet gum is widely used in the veneer industry. Longleaf and slash pine are sources of naval stores as well as timber. The southern pine is also used for the manufacture of kraft paper. Climatic conditions, with a long growing season and plenty of rainfall, favor rapid tree growth, and the South is and should continue to be one of the most important timber producers of the United States.

In southern Florida, the coastal forests contain subtropical tree species, but the area is too small to be of commercial importance. Royal and thatch palms, mangrove, wild fig, palmetto, wild olive, and buttonwood are among the tropical species.

Plains. On the semiarid Great Plains the only trees were in narrow corridors (gallery forests) of cottonwoods along the flood plains bordering the larger streams, and a few stunted junipers in the badlands. Outlying ranges of the Rockies, like the Black Hills of South Dakota and several mountain masses in central Montana, support forest "islands" of lodgepole pine and other softwoods because of the greater rainfall they enjoy. In general, however, the Great Plains never had any large quantity of useful timber.

Rocky Mountains. The forests of this part of the country extend from a point north of the Canadian border across the whole width of the United States and southward into Mexico; they can be divided conveniently along the southern boundary of Wyoming into the northern and southern Rocky Mountain forest regions. The trees are limited mainly to the rainy and snowy mountain slopes, high valleys, and elevated plateaus. The associated lower plateaus and valleys, like the surrounding plains, support merely grass, sagebrush, stunted cedars, or thorny brush. The principal tree species in the Rocky Mountain and plateau country is the ponderosa, or western yellow pine, a drought-resistant species that may thrive with a rainfull as low as 15 inches annually. The lodgepole and other pines, firs, and spruce predominate in the higher mountains. The northern Rockies, especially in the mountains of Idaho, have important forests of western white pine mixed with larch (tamarack), firs, cedar, and other conifers. Small stands of aspen, alder, and cottonwood grow locally. When statistics of standing timber have been given in this book for the Pacific Northwest, some of the northern Rockies in Washington and Oregon have been included. The forests of the Colorado Plateau and the Great Basin have been included with those of the southern Rocky Mountains.

West Coast. From the Cascade Range to the Pacific in western Washington and Oregon grows the Douglas-fir forest, which contains today the largest amount of virgin standing timber remaining in the country (Fig. 99). Cedar, western hemlock, Sitka spruce, true firs, and other trees are associated with Douglas fir. Some maple, aspen, and oak are associated with the conifers. Along the coast of southwest Oregon grows the valuable Port Orford cedar and small stands of myrtle. Climatic conditions are so favorable for forest growth that the board feet of timber per acre greatly exceeds that of any forest region in the eastern United States.

From the Oregon boundary southward to the Golden Gate occurs the redwood forest in a band only 25 to 50 miles wide, exposed to abundant rains and fogs of the Pacific. The inland forests of California are mainly

their wood lots. Valuable lumber for furni ture, flooring, interior finishing, barrels, wagons, boatbuilding, and other wooden articles and items came from this forest. Hardwood trees also have wide use as fuel, mine props, and railroad ties. Many woodworking plants were established near these supplies of timber; among the furniture-making centers are the cities of Grand Rapids, Michigan; Bloomington and Shelbyville, Indiana; and Chicago. South Bend, Flint, and Detroit were famed for wagons and carriages long before automobiles were invented. Louisville, Kentucky, leads in the manufacture of baseball bats, and St. Louis makes bowling pins and alleys.

Further Shift of the Industry. Having exhausted the resources of the Lake states, the lumbermen went southward to the virgin-pine forests of the Gulf and Atlantic coastal plains and westward to the Pacific. Today the South and the West contain over 78 per cent of the remaining commercial timber of the United States. The South is convenient to water and rail transport to the northeastern markets, but both the Rocky Mountains and the Pacific coast areas are distant from large consuming markets.

Conditions in the South. Conditions for lumbering in the South were different from those of the Lake states and New England. There was no snow to serve as roads in winter, but lumbering operations in the rather open forests of yellow pine could be carried on throughout the entire year. The level or rolling land favored the building of logging railroads and the use of machinery (Fig. 128). Mill towns developed both on the coast (Brunswick, Georgia) and at interior centers (Monroe, Louisiana). Furthermore the long growing season and abundant rainfall favored the rapid growth of trees and the perpetuation of the industry, although unfortunately over large areas the forests have been destructively cut with no thought of keeping them productive. Supplies of hardwood in the interior sections are used for furniture making, as at High Point and Gastonia, North

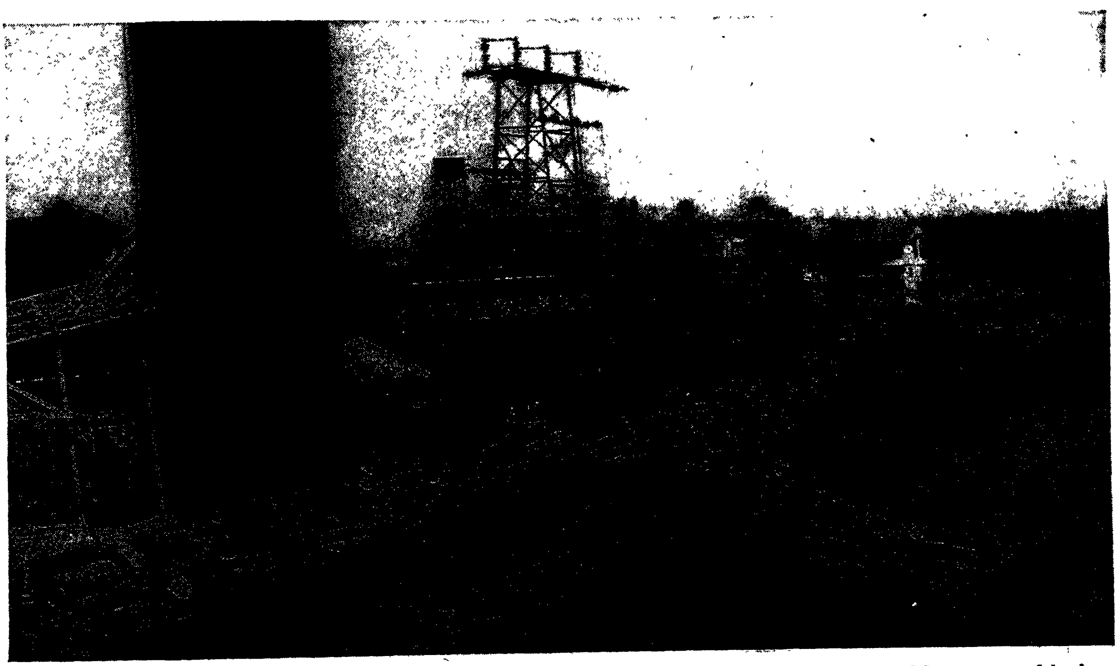

FIG. 128. Log train ready to dump logs into millpond at Crossett, Arkansas. (Note evidences of heavy use of hydroelectric power at this mill.) Burner at the left is used to dispose of wood waste. (*Photograph by L. J. Prater, courtesy of U.S. Forest Service.*)

Carolina, and in Arkansas and other woodworking locations.

The West Coast. Climatic conditions were favorable for the growth of dense stands of large trees in both the Douglas-fir forest of the Northwest and the timberlands of northern California and for logging during most of the year. The enormous size of the firs, cedars, and redwoods led to the application of machinery to lumbering operations (Fig. 129). Railroads, trucks, donkey engines, spar trees, caterpillar tractors, and other loading devices combined to produce lumber at a faster rate than was ever known before. Sawmills were built so large that a single concern equipped with band saws could cut twice as much lumber as the 400 circular saws that all the mills of Bangor boasted in its prime.

In the Northwest the greatest lumber-sawing towns had the advantage of a tidewater location; they brought the logs by water, rail, and truck to the mills from the forested country inland as far as 100 miles away. Tacoma, Seattle, Everett, Bellingham, Longview, and the Grays Harbor cities of Aberdeen and Hoquiam in Washington; Portland and Coos Bay in Oregon and Eureka, California, are among the lumber-sawing ports. Inland cities like Eugene, Bend, and Klamath Falls in Oregon and Lewiston, Idaho, are also important in the industry. Oregon and Washington top all other states in their output of lumber. Many pulp and paper mills were built to utilize the spruce and some inferior woods for their products. Some of the best clear logs of Douglas fir are made into veneer and plywood, which find wide use in furniture and construction work.

Stand and Cut of Timber in the United States. According to a survey of forest resources in the United States made by the U.S. Forest Service, the total stand of timber in 1945 was 470 billion cubic feet, distributed 51 per cent in the West, 28 per cent in the South, and 21 per cent in the North and Northeast.

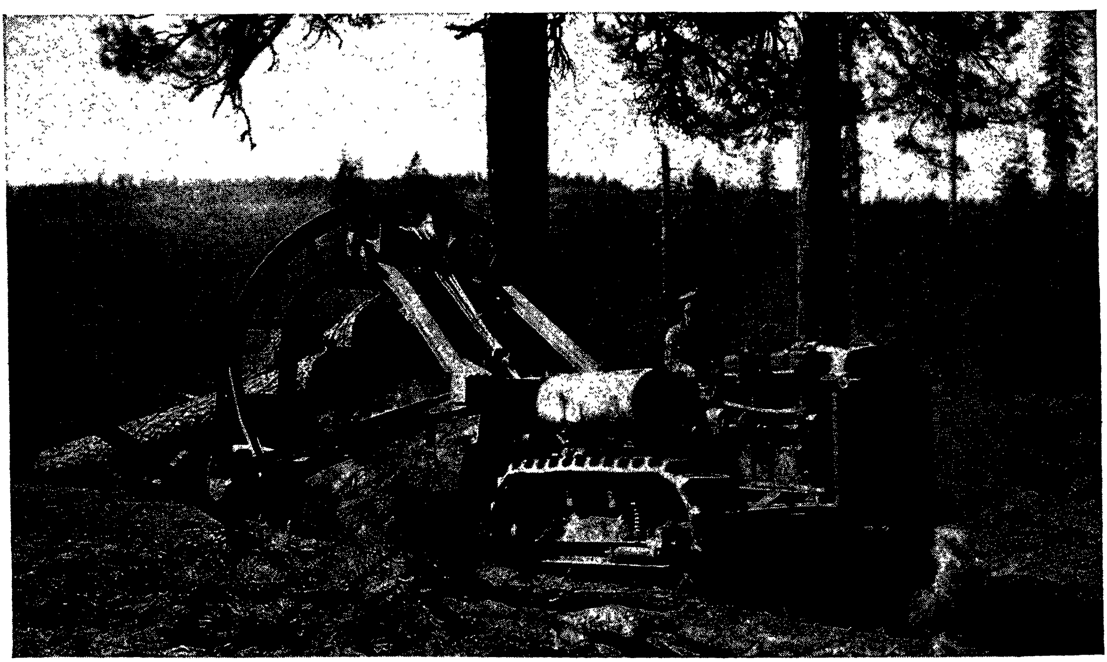

FIG. 129. Modern method of handling sawlogs in a Western forest. This is known as "cat (caterpillar) logging," and by this means it is possible to carry on lumbering in places too far from rail or highway transportation. (*Photograph courtesy of the Caterpillar Tractor Corporation.*)

TABLE 3. TIMBER STATISTICS OF THE UNITED STATES, 1945 *

Region	All timber		Saw timber		Annual drain,† all timber, million cubic feet	Lumber, million board feet
	Billion cubic feet	Per cent of required growing stock	Billion board feet	Per cent of required growing stock		
New England....	25	78	58	67	761	864
Middle Atlantic..	27	57	62	48	846	1,361
Lake states......	23	66	50	58	747	1,170
Central states....	21	40	44	44	1,201	1,479
Plains...........	4	100	6	100	118	36
Total, North...	100	59	220	54	3,673	4,910
South Atlantic...	36	106	97	76	1,596	3,536
Southeast........	54	63	136	48	3,022	6,867
West Gulf.......	41	69	105	50	1,842	3,819
Total, South...	131	73	338	54	6,460	14,222
Pacific Northwest	146	105	631	150	2,618	10,877
California........	45	100	228	177	490	2,496
Northern Rockies	33	79	127	161	316	1,499
Southern Rockies.	15	79	57	127	104	387
Total, West....	239	98	1,043	155	3,528	15,259
Total United States.....	470	791	1,601	94	13,661	34,391

* U.S. Forest Service.
† The annual drain includes losses from fire, insects, and diseases.

The stand of saw timber was 1,601 billion board feet, divided into 1,296 billion board feet of soft woods and 305 billion board feet of hardwoods. As a matter of interest, this figure represents 43 per cent less standing saw timber than was reported in 1909. It also represents 9 per cent less than for 1938. The lumber cut in 1944 was 34 billion board feet. The entire drain on the volume of all timber was 13,661 million cubic feet. Of this, sawed lumber accounted for one-half; fuel wood for 16 per cent; pulpwood for 10 per cent; and ties, posts, poles, and miscellaneous items for 15 per cent. About 3 per cent of the drain came from fires and 6 per cent from insects and diseases.

The Forest Service estimates that our forests under their present conditions of growth and cutting can grow only 79 per cent of the required stock to supply our future needs for timber. This indicates the urgent need for improvement in the handling of our forests. Improvement is especially needed in the management of our privately owned forest resources in the South and the North, to ensure that those forests more nearly approach their growth capacity. The situation regarding hardwoods, comprising 19 per cent of the nation's total stand of saw timber, is particularly serious because of the slowness with which this type of forest grows compared with the softwoods. The hardwood forests are about evenly divided between the northern and the southern states and are being depleted rapidly in both regions.

National Forests. As an aid to the conservation of forests, the United States created the first forest reserve in 1891, but most of the national forests (as they were renamed in 1907 to eliminate the implication that they were withdrawn from use) were established from the remaining areas of publicly owned forest land by President Theodore Roosevelt soon after 1900. Since the more accessible forest land had already passed into private ownership, most of the forest reserves were located in remote mountain regions of the West. In 1911 Congress passed a law permitting the government to purchase land; and by this method and by donation national forest lands were acquired and established in the White Mountains, the Appalachians, and smaller areas in the Lake states and the Ozarks. The gross area of the national forests in the 48 states is approximately 218 million acres, but not all the included land has commercial stands of timber because large areas of inferior tree types occur in high mountains within national forest boundaries. The national forests include more than one-third of the forested area of the United States (Fig. 123) but less than one-third of the standing timber. National forests in Alaska cover nearly 21 million acres and contain the best timber in the territory.

The national forests were created "for the purpose of securing favorable conditions of waterflows, and to furnish a continuous sup-

ply of timber for the use and necessities of the citizens of the United States." (Act of June 4, 1897.) By direction of the Secretary of Agriculture when the national forests were placed under his administration in 1905, "all land is to be devoted to its most productive use for the permanent good of the whole people, and not for the temporary benefit of individuals or companies, . . . and where conflicting interests must be reconciled the question will always be decided from the standpoint of the greatest good of the greatest number in the long run."

National forests have multiple purposes and uses. The forests provide a source of income, since timber is sold with the requirement that the logging must be done in specified ways to ensure the perpetuation of the forests and reduce the fire hazards. There is a very close relationship between national forests and the consumers of water for industrial, agricultural, and domestic use. Most great cities and irrigation projects of the western states secure their water from mountain areas included in the national forests. The Great Valley of California, the Yakima and Wenatchee valleys in Washington, and the irrigated sections of southern Idaho and Utah are examples.

Forests have great value as protectors of watersheds, and they help to prevent floods and to supply water for power and municipal use. In the East, national forests cover the crests of the Appalachians and White Mountains, which include the headwaters of many streams used for hydroelectric power and industrial and domestic supply. In the United States more than 1,000 cities and towns obtain all or most of their water from sources in national forests. Examples include Los Angeles, Denver, Portland (Oregon), Ogden, Phoenix, and Little Rock. The national forests furnish much summer grazing for sheep and cattle; and, by supervision and control over the livestock, the forest is protected for growth of timber and watershed purposes.

To an increasing degree, the national forests have become summer playgrounds for campers, tourists, fishermen, and hunters, for whom the Forest Service maintains numerous campgrounds at convenient and scenic spots. There are 90,000 miles of streams in the national forests, which provide some of the best fishing in the United States.

Timber Resources of the World

The continents have forest resources of great diversity as the natural result of several factors, including climate, relief features, amount of former forested land now cleared for farming, the extent of exploitation of their forest resources, and differences in types of trees. Estimates of the forest areas of the world differ widely, depending on the authority, and estimates of the volume of timber differ even more than those of the areas because detailed information is not available for many regions.

According to the U.S. Forest Service, the forest area of the world is approximately 9,000 million acres. Lumber and other timber products are generally quite bulky and form important items for both domestic and foreign trade, especially since sources of supply are often remote from consuming markets.

For convenience, commercial timber is divided into softwoods, hardwoods of the mid-latitudes, and tropical hardwoods. Softwoods are obtained only from conifers and other trees having needle leaves. All broadleaf trees are called hardwoods whether the wood is actually hard or not.

Softwoods. The taiga and forests located within the areas of west-coast marine climate are made up principally of softwoods; they supply large quantities of lumber and pulpwood in North America and in Europe. The taiga lands of Siberia constitute an important reserve of softwood for lumber and pulpwood for export and future use in the Soviet Union. New Zealand, Tasmania, and south-

TABLE 4. WORLD FOREST AREAS
(After U.S. Forest Service)

	Per cent of total*
United States and Alaska	8.1
Canada, Newfoundland	9.3
Mexico, Central America, West Indies	2.4
South America	20.0
U.S.S.R., Europe and Asia	26.2
North Europe	1.5
West and central Europe	0.7
East Europe, except U.S.S.R.	0.8
South Europe	0.6
Middle East and North Africa	1.1
Central and South Africa	14.1
East Indies and Philippine Islands	5.1
Asia, except Middle East and U.S.S.R.	8.6
Australia, New Zealand, Pacific Islands, and New Guinea	1.5
Total	100.0

* Total forest area, 9,000 million acres.

ern Chile produce minor amounts of softwood, although true conifers are not native to the lands of the Southern Hemisphere. Humid warm temperate or subtropical regions, as in our own South and in parts of southeastern Brazil where the so-called Paraná pine grows, have extensive softwood forests. Softwoods also grow on the mountains of the Northern Hemisphere, where they extend some distance into the lower latitudes. Foreign nations having large reserves of conifers, that is, softwood, are the U.S.S.R., both European and Asiatic; Canada; and northern Europe around the Baltic Sea in Norway, Sweden, Germany, Poland, and Finland. Austria, Switzerland, and Rumania also have extensive pine forests. Some softwood is available in Cuba and the Bahamas and in the mountains of Mexico.

Temperate Hardwoods. The land that supported hardwood forests in the mid-latitudes generally possessed fertile soil and a favorable climate, and wide areas of this type of forest land in western and central Europe, the eastern United States, and northern China, Japan, Korea, Manchuria, and southeastern Siberia have been cleared for agriculture. Hardwood is exported in some volume from the Balkan countries, especially Yugoslavia, and local supplies are cut in western Europe. A little hardwood grows in the southern Andes. Australia produces only hardwood lumber, principally from various varieties of eucalyptus.

Tropical Hardwoods. In the tropical rain forest many kinds of hardwood trees flourish, but lumbering is difficult and expensive. The heat and humidity make labor less efficient, trails and roads are difficult to clear through the tangle of vegetation, and much of the timber is remote from seaports and rivers (Fig. 130). Species of trees having commercial value do not exist in solid stands as in the northern coniferous forests but occur widely scattered, making it hard to find and cut desired timber. Some cabinet woods and other special timber—mahogany, rosewood, teak, and ebony—come from the tropics, but today most of the accessible commercial forests of the world are in the mid-latitudes of the Northern Hemisphere. The utilization of the tropical hardwoods presents a challenge to lumbermen and users of wood. The tropical rain forests cover large areas and unquestionably contain much timber of species whose usefulness has not been discovered. Furthermore tree growth is rapid, and it is possible that the forests might be so managed as to increase the reproduction of the trees that are known to be useful and to reduce the number of undesirable trees. In the future our own country may have to depend upon the tropics for much of our needs for hardwood.

World Resources and the United States Supply. The area of the forested land of the world is estimated at about 9,000 million acres, distributed among the continents in the following proportions: Asia, 28 per cent; South America, 28 per cent; North America, 19 per cent; Africa, 11 per cent; Europe, 10 per cent; and Australia, 4 per cent. Of the world's forests, conifers, now being rapidly exploited, cover about 2,660 million acres; temperate hardwoods, 1,200 million acres; and tropical hardwoods, 3,640 million acres. The United States normally cuts as much lumber per year as the rest of the world combined,

FIG. 130. Tractor hauling a large mahogany log in a tropical rain forest in Central America. (*Photograph courtesy of the Mahogany Association, Inc.*)

suggesting the rapidity with which our forest resources are being depleted. Yet, if we get all our commercial forest lands under good management and keep them productive, we can continue to produce on the present scale or at even a greater rate. We have enough forest land if we use it properly. Future expansion of the world supply of softwoods must depend on the coniferous forests of the U.S.S.R. and of hardwoods of the tropical evergreen forests of South America and Africa. The annual drain on United States forests continues to exceed the annual growth, which indicates the necessity for an adoption of a sound conservation policy for both public and private forest lands.

A Forest Program for the United States. A sound forest program for the United States involves both short-range and long-range activities, which are intended to make our country attain a balance between consumption and growth of timber. At present there is sufficient forest land to grow all the timber we need, provided that the forests are properly managed. Any effective forest program for our country must include the private lands, which comprise about 75 per cent of our 461 million acres of commercial forests. Only a start has been made in reaching the 3¼ million farm wood lot owners. Education and group demonstration projects would be helpful in this field. Some states have substituted a severance tax for the usual system taxes on land devoted to growing timber. This encourages both the planting of trees and the better handling of existing wood lots. Some 3¼ million acres of publicly owned land that is partly or wholly denuded of forests should be brought into productive condition by planting as quickly as possible. More effective protection against fires, insects, and diseases in forests is essential. Cooperative sustained-yield units may be the solution in certain areas. It may become desirable to establish benefit payments for forest conservation, as is done with soil conservation. Certainly forest research and the dissemination of information concerning forest problems will assist in the development of forestry and the utilization of forest products.

Forest Depletion

Natural Enemies of Forests. Many natural causes lead to destruction of forests, although man himself is the greatest destructive agent in the world today. In a condition of nature it is obvious that the destruction by natural causes must balance the growth of timber in a mature forest. Among the causes for losses are insects, fungus diseases, fire, wind, animals, winterkilling, and drought.

Insects. The damage wrought by insects in the forest is estimated to destroy resources worth many millions of dollars annually. All parts of the trees are subject to attack by insects. The seeds may be eaten by maggots, cone beetles, and the larvae of certain moths. Grubs, weevils, and beetles attack the seedling, the sapling, and the roots, bark, limbs, trunk, and foliage of both young and old forest trees (Fig. 131). Wood borers work on sound trees and fallen logs. Bark borers may kill trees by girdling the trunk in the inner bark (cambium layer) just under the outer bark. It has been estimated that the western pine beetle (Fig. 132) has killed 25 billion board feet of pine timber during the outbreak periods from 1917 to 1943. The losses were nearly equal to the cut of pine lumber for the period. The ponderosa, or western yellow pines, are most subject to attack by this pest.

Hardwood trees have their insect enemies; locust borers wreak much harm in this type of tree. Caterpillars of the tussock moth, gypsy, browntail, and other moths; sawfly larvae; and adult beetles may injure both conifers and broadleaf trees by devouring the foliage and thereby weakening trees and sometimes killing them. Aphids and various scales suck the juices of plants and are special enemies of shade and fruit trees. The insects that kill trees increase the fire hazard and make tree reproduction and reforestation more difficult to achieve. Overmature trees and those damaged by fire or some other cause are easy prey for insects.

FIG. 131. Whitebark pine trees in Deerlodge National Forest, Montana, killed by the ravages of pine beetles. (*Photograph courtesy of the U.S. Forest Service, Department of Agriculture.*)

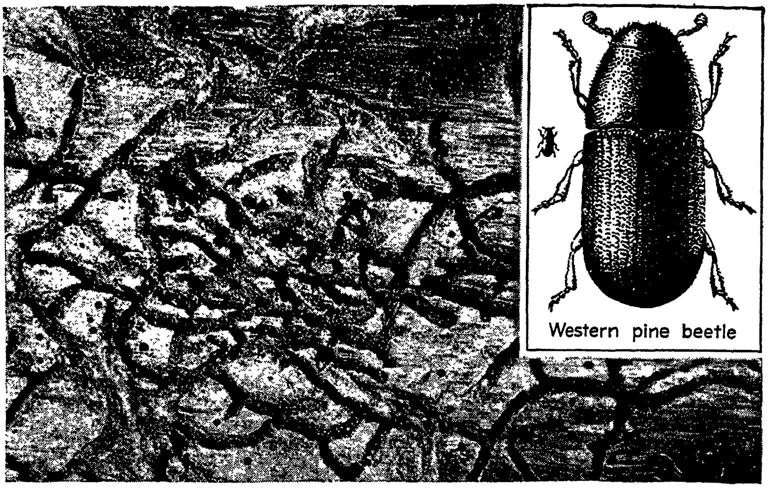

FIG. 132. Western pine beetle and its damage to wood. This insect has caused great loss in the forests of the western United States. (*Illustration courtesy of the U.S. Forest Service.*)

Insects preying on forests have natural enemies that normally keep them in check. These include mites, birds, rodents, other insects, and bacterial or fungus diseases. When a pest increases in numbers, its enemies also tend to increase and ultimately control it. Woodpeckers, nuthatches, and warblers are among the birds feeding upon eggs, larvae, scale, and other insects. Squirrels, shrews, and mice eat insects, especially in the hibernating pupal state. Sprays may help to control pests in cultivated or shade trees, and airplane spraying of forest trees has been done successfully in recent years on an experimental scale. For example, 387,000 acres were sprayed in 1947 against the tussock moth in Idaho. Cutting and burning of infested trees also helps to prevent the spread of serious insect epidemics.

Tree Diseases. Fungi work most havoc in mature forests where they serve a useful purpose in helping to cause decay of fallen timber that might otherwise accumulate to an extent that would increase the fire hazard and might interfere with natural reseeding of the forest trees. Fungi reproduce by means of spores carried by the wind; and they find entrance into trees, especially through injured branches or broken bark, from which point of infestation the disease spreads until the wood is softened and decayed and becomes worthless for lumber.

Certain special diseases of trees, usually imported from abroad where the host species of trees may have developed immunity, have proved very deadly when introduced into America. One of these is the Dutch elm disease (Fig. 133) for which no remedy is known. Hence the only method by which this disease can be checked is by immediately destroying all known elm trees infected with the disease in the hope that uninfected elms will escape. The chestnut blight, another serious infestation, was introduced from the Orient into New York State in 1904. Unfortunately strict quarantine measures were not taken, with the result that practically all the American chestnut trees in New England, New York, and Pennsylvania, and southward throughout its entire range are infected, and most of them have been killed (Fig. 134). Apparently the American chestnut is doomed by this blight, for which no remedy has been found and no immune strain developed.

Throughout the nation, a dangerous infection affects the white pine (Fig. 135). This white-pine blister rust has a peculiar life history. The disease does not spread directly

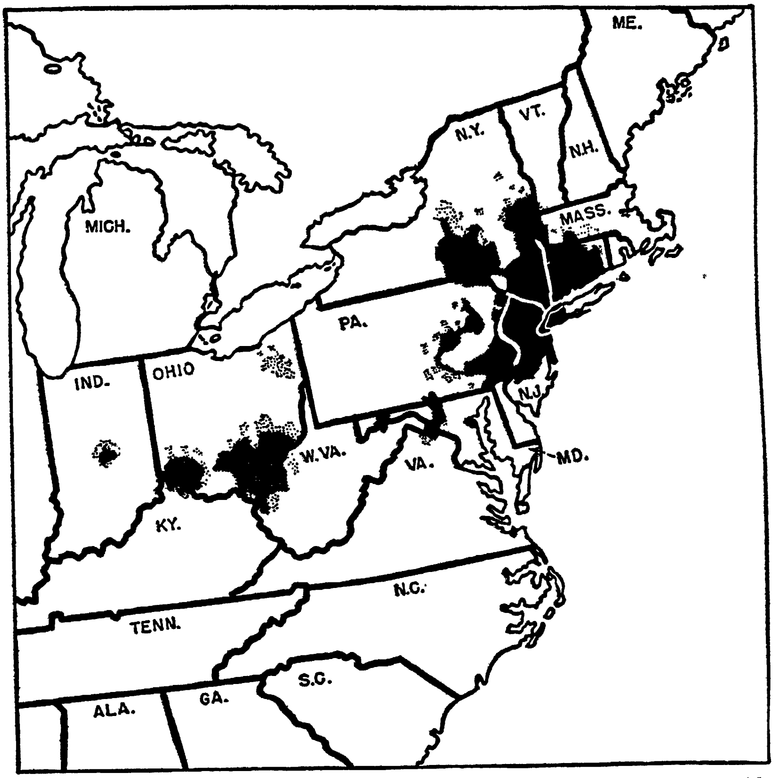

FIG. 133. Extent of the Dutch elm disease infestation. Area quarantined in 1941 is shown in black (11,617 square miles); diseased area in January, 1946 (23,659 square miles), is shown by crosshatching; diseased area in November, 1946, is shown by dots. (*Courtesy of American Forestry Association.*)

from one infected pine tree to another white pine, but only through an intermediate host, which must be a species of *Ribes*, usually the wild black currant and gooseberry. From these shrubs the spores again infect the white pine. The white-pine blister rust spreads only among pine trees having five needles in a bundle and does not affect the lodgepole or the yellow pine. The disease has spread throughout most of the range of all five-needle pines in the east, north, and west. Attempts to control white-pine blister rust provide for the elimination of all wild currants or gooseberries in and near the stands of white pine.

Damage by Animals. Animals grazing in the woods can do serious damage to both seedlings and older trees. Seedlings and young growth, especially of hardwoods, are often destroyed by browsing by horses, cattle, sheep, and goats. The animals may also trample out seedlings or break down the young growth. In the South pigs root out and eat the inner bark of pine seedlings, and they also consume seeds and nuts of trees, thereby preventing their reproduction. Stock sometimes injure larger trees by nibbling at the bark. The trampling by stock may injure mature trees by exposing and wounding their roots and by compacting the soil so that much of the rainfall runs off instead of being absorbed. Domestic sheep and goats may also seriously damage woodlands. Regulation of grazing is essential if a forest stand is to remain productive very long. Some wild animals, notably the porcupine, injure trees by girdling the bark. Chipmunks, squirrels, and other rodents devour the seeds, and beavers are sometimes destructive along streams.

Storms and Other Minor Causes of Forest Injury. Other causes for natural destruction

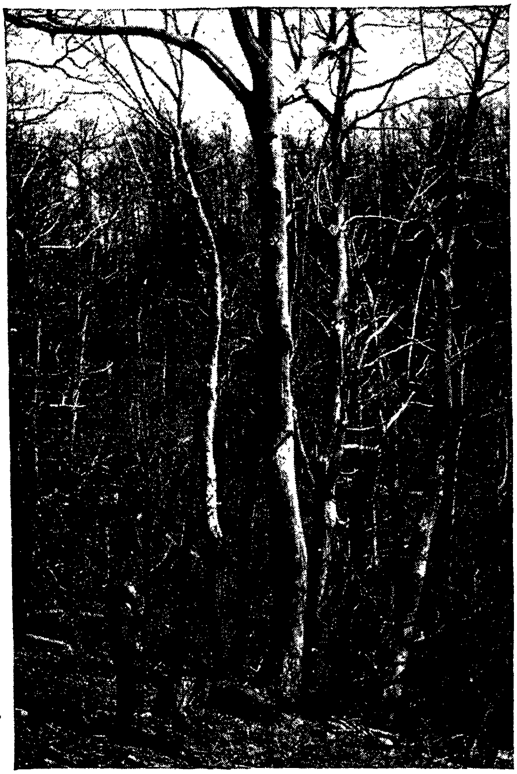

FIG. 134. Large chestnut tree killed by chestnut blight, standing in the Chattahoochee National Forest, Georgia. (*Photograph courtesy of the U.S. Forest Service, Department of Agriculture.*)

of the forests include tornadoes and other windstorms and lightning. For example, a great "blowdown" in 1921 on the Olympic Peninsula caused a loss of at least 5 billion board feet of timber. The New England hurricane of September 21, 1938, blew down an estimated 13¼ billion board feet of timber (Fig. 46). Destruction of trees by winds depends on the velocity and exposure to the wind; the type, age, and health of the trees; condition of the soil, particularly if water-soaked; injuries inherent from gathering turpentine or maple sugar; weakness resulting from insect ravages or fungus growth; and the size and depth of the root system. Lightning, ice storms, sudden changes from thaws to freezing temperatures, and extended drought may kill trees.

Forest Fires. The most damaging of all destructive agents in the forests are fires. Forest fires destroy timber in all states of the Union, and the total number of annual fires may mount into the hundreds of thousands (172,000 in 1946) with annual damage of 30 to 40 million dollars. Some fires get completely out of control and have been known to burn over more than a million acres of forest land, destroying several billion board feet of timber in single "burns." The worst forest fires generally come when weather conditions make their control practically impossible unless they are attacked immediately after they start. Hot, dry, windy weather furnishes ideal conditions for the spread of fire. In many forested sections, when the relative humidity falls below 20 per cent, forest-fire warnings are issued because the low humidity causes the litter on the forest floor to become highly combustible

FIG. 135. Diseased white pine seedling from a forest in Massachusetts. When blister rust attacks these trees, seedlings invariably die. (*Photograph courtesy of the U.S. Forest Service.*)

and fires will spread rapidly if started. Other factors to be considered in evaluating fire hazards include wind velocity and direction, the length of the period since the last rain, the type of fuel available for the spreading fire, and the dryness of that fuel. When conditions favoring "fire weather" prevail, all clearing of land by fires should be stopped; coal-burning locomotives should be outfitted with spark arresters; and campfires and smoking in the forests should be prohibited except at designated campgrounds. In national forests and some private lands, lumbering operations are sometimes stopped until the dangerous weather condition has passed. In 1936 the terrible Tillamook fire in Oregon burned 6 billion board feet of lumber in 2 days. It was started by friction during logging operations, and it spread because of a hot dry wind through forests that were ordinarily too damp to burn easily.

Once fire is started from any cause during the dry season, there is bound to be much combustible material in the woods that will feed the flames, especially after lumbering operations have left the ground covered with dead branches and discarded trunks of trees. This "slash" becomes very combustible when dry, and in some national forest operations loggers are required to pile the tops and brush after cutting and where practicable to burn the refuse when it is too wet for fire to spread. It is much easier to prevent fires than to extinguish them once they have begun. Fire-control measures begin with fire prevention.

Causes of Fires. Forest fires may occur from both natural and human causes. The latter come from carelessness and intent and are therefore preventable. The principal natural cause of fires is lightning, especially in the western part of the United States where thunderstorms are not always accompanied by sufficient rain to extinguish the fires started by lightning bolts. More than 300 fires have been started in a single day in one national forest in Idaho, and in one summer 14 per cent of the area of the Kaniksu Forest of northeastern Washington and northwestern Idaho was burned over because of the spread of lightning fires. Nothing can be done to stop the ignition of the forests by lightning, but watchful care during the thunderstorm season may prevent excessive destruction. The building of roads and trails so that a fire can be reached quickly by a force of fire fighters aids in extinguishing or controlling the fires before much damage is done. Fire fighters and supplies to aid them are sometimes transported by airplanes and are dropped safely by means of parachutes.

Carelessness in clearing land and the burning of brush by farmers is an important cause of fires. This combines with carelessness by campers and smokers in the forest to cause nearly one-third of all fires. Sparks from locomotives and donkey engines, and backfiring of automobile engines are important causes of fires. In some sections, especially in the southern states, it is the custom to burn off the dry grass in the forest in the belief that this practice will improve the quality of the forage and destroy insects and snakes. Such ground fires have slight effect on mature trees, but by killing or injuring the seedlings they may seriously affect the natural reproduction of the forest cover. Fortunately some progress is being made in stopping this poor practice. Some fires are deliberately incendiary, being set because of fancied wrongs, to make work in fire fighting, and for other reasons. Ninety per cent of forest fires are man-caused, mostly by carelessness.

Ground and Crown Fires. Fires may not be hot enough to kill mature trees, especially those provided with thick bark for protection; but, even when the fire is restricted to the ground, serious damage results. These ground fires kill the seedlings that will reproduce the forest. They destroy undergrowth that helps to hold the soil by retarding the runoff after heavy rains. Forest leaves and other litter, which supply needed humus to the ground and help prevent undue erosion, are likewise destroyed by ground fires. Even if fire does not immediately kill a tree, it may leave injuries that allow the entrance of

insects and disease-producing parasites and fungi, which will slowly kill the tree or weaken the wood. Soil deprived of humus and its covering of brush is subject to erosion. Its fertility and its capacity to hold water are much lessened by repeated burning of the ground cover. The value of the forest as a home for wild life is temporarily destroyed, and many birds and game animals perish during fires, which also destroy the natural beauty of the forests that make them attractive to campers and tourists.

When high winds occur during a time of low humidity, an entire forest may become ignited from the litter on the ground to the treetops, producing what is called a crown fire (Fig. 136). Crown fires totally destroy all plants and animals, even the largest trees that lie in the path of the flames. It may take years or even half a century before an area devastated by a crown fire can again support a worth-while forest. Man can fight ground fires by trenching or with water pumped by portable engines, but the only thing that will stop a crown fire is a prolonged general rain, a shift in the wind, or the fire burning itself out to a place where no fresh fuel exists.

Protection against Fire in Forests. As an aid to the protection of the forest against fire, the government maintains a system of fire-lookout stations in all its national forests, placed on the highest peaks in mountainous areas or on the tops of artificial towers on flatlands. When a fire is spotted, headquarters is notified by telephone. Men and supplies to fight the fire are rushed to the site by roads and trails maintained for that purpose. Many private landholders and states cooperate in the maintenance of fire-lookout service. The fire hazard in forests can be reduced by piling brush carefully after lumbering operations and allowing the burning of debris and the clearing of land only when the forests are too wet to make this hazardous.

Careless versus Selective Logging. *Careless Logging.* Another cause of unnecessary injury

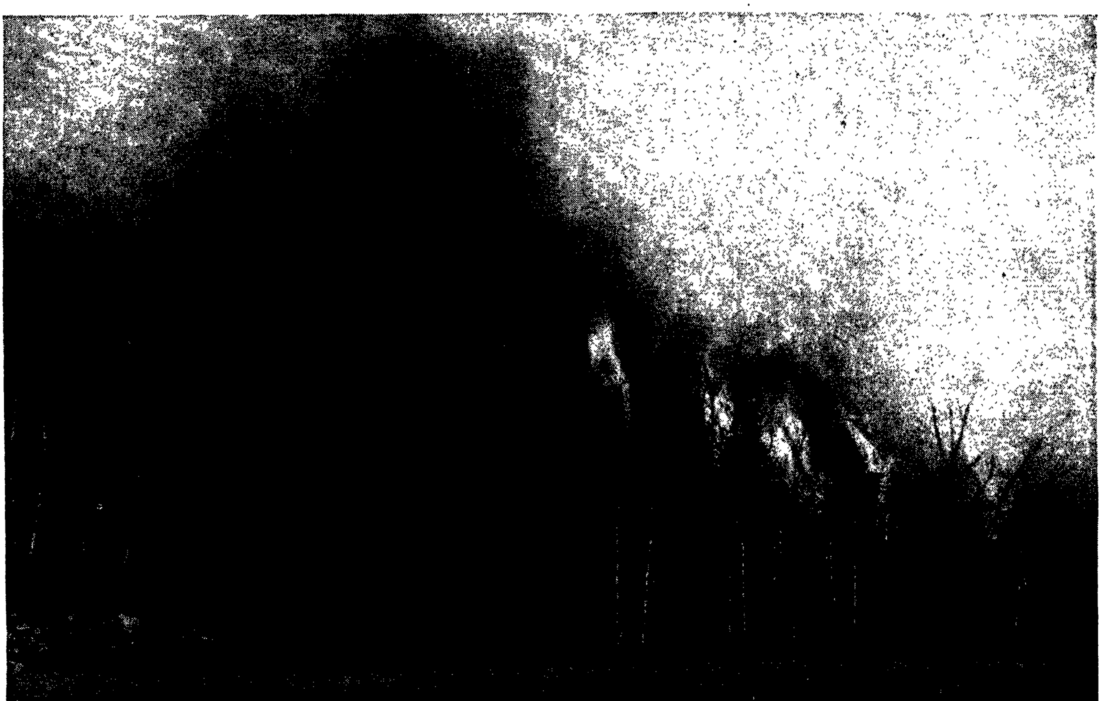

FIG. 136. Crown fire in Rhode Island woods. This hill slope will be a worthless expanse of dead or dying trees after the passage of the fire. (*Photograph courtesy of U.S. Forest Service.*)

Reforestation. Where good logging practice is used, natural reproduction will perpetuate timber growth; but on lands denuded by improper logging or fire, planting may be necessary to restore timber growth. Planting trees is practical from the economic standpoint at times, but it may sometimes be too slow and expensive to attract private capital looking for investment. Hence much tree planting devolves upon the government. In the northern United States, where it takes from 75 to 100 years for a tree to become large enough for a saw log, an individual cannot ordinarily wait for any financial returns from the tree plantings. In the southern states, because of the length of the growing season and the abundant rainfall, pine trees grow very rapidly and may be cut for saw logs in as little time as 30 years, and for pulpwood in 20 years in some places. Consequently reforestation in the South offers a good opportunity for investment. The artificial planting of trees and the protection of naturally seeded ground from injury by fire and roaming livestock is an urgent necessity in the southern states, where the natural conditions for the growth of timber are among the most favorable of any in the nation. In national forests there is official control so that grazing animals are never sufficiently numerous to cause serious damage to young growth; but on privately owned land where woods are used for pasture, damage from overgrazing frequently occurs and control is greatly needed.

Decline of Towns and Industries. One result of unnecessary destruction of the forests is the decay of towns dependent upon woodworking industries. Hundreds of sawmill towns in all parts of the once forested country have almost completely disappeared, and many others have sadly deteriorated upon the closing of their mills. Yet conservative methods of lumbering would have permitted the forests to continue to yield a crop of timber annually, and the abandoned towns would remain prosperous sawmill centers for an indefinite period. A few companies are carrying on their lumbering operations by methods that perpetuate the forest and set an example that should be followed by the rest of the woodworking industries. Even furniture factories find it difficult to maintain themselves when they have exhausted the immediate supply of hardwoods and find it necessary to draw on distant supplies. Oftentimes indeed factories are compelled to close in the older lumbering districts, and new factories that are near supplies of hardwood timber take their places. The veneer industry, by slicing valuable logs into thin pieces that are glued on the surface of cheaper woods, furnishes a method of conserving more valuable supplies by substituting cheap and more abundant woods.

Problems

1. Compare lumbering operations in the tropics and the taiga.
2. What are the principal problems of lumbering in tropical rain forest regions?
3. What is meant by the expression "virgin forest"?
4. What problems were faced by the westward-moving pioneers in the United States after they crossed the Mississippi and reached the grasslands where timber was not abundant?
5. After our present forests in the Pacific Northwest have been cut, what alternative have we if we continue to use lumber at the present rate?
6. Each of the following woods has qualities that make it particularly desirable for special uses. What are the qualities, and for what special purpose are these woods used? Cypress, redwood, teak, balsa, mahogany, ash, hickory.
7. How has the extensive use of plywood or veneer in recent years conserved our timber supply?
8. Why are lumber towns in the Pacific Northwest somewhat more stable than lumber centers in other parts of the country?
9. List the principal lumber-exporting nations of the world and the principal lumber-importing nations.

10. What relation does your answer to Problem 9 bear to total population of these nations?
11. Why are the direction and control of timber reserves a matter of interest to the Federal government?
12. About one-half of a saw log is wasted by present practices. Suggest ways by which the waste wood can be made into useful products.
13. What are some chemical products made from wood?

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Note: The Superintendent of Documents, Washington, D.C., will furnish a list of publications on different aspects of forest conservation. U.S. Forest Service, Department of Agriculture, Washington, D.C., will supply a list of recent publications upon request.

CHAPTER 12: *The Changing Face of the Earth*

The variations in the surface of the earth have resulted from natural forces working slowly but steadily for countless ages. The same forces affecting the earth today, seemingly insignificant in themselves, are capable of accomplishing vast changes if given the millions of years available in the geologic past. In general the natural features of the earth's surface result from a constant conflict between forces tending to elevate or build up the land and others continually striving to reduce all irregular surfaces to featureless plains. The arrival of man complicated the operation of many natural agencies, since many of his activities, including cultivation of the soil, destruction of grass and forests, and construction of dams and ditches, hasten or delay the various forces that affect the land surface. Human activities such as agriculture and housebuilding greatly alter the cultural landscape, and those parts of the earth occupied by civilized man have experienced the greatest changes in the natural landscape.

Surface Features Vary in Magnitude. A convenient classification of the surface features of the earth is based on their arrangement in a descending order of magnitude. The surface features of greatest size are those vast depressions occupied by the oceans and the enormous elevated blocks of the continents. Authorities differ in their recognition of the number of ocean basins and continents; but in general those accepted include the Pacific, Indian, North Atlantic, South Atlantic, and Arctic basins, and the continents include Eurasia, Africa, North and South America, Australia, and Antarctica.

Interrupting the surfaces of the major relief features are those of a second order of magnitude, including the cordilleras of associated mountain ranges (the Andes, Himalayas, Rockies), the large plains and basins (North European Plain, Great Plains, Congo Basin), plateaus (Tibet, Colorado), oceanic troughs or *deeps* (south of the Aleutians, parallel to the west coast of South America), and submarine plateaus (North Atlantic). The land features of the second order form the dominant framework of the continents (Fig. 139). The ocean troughs typically are elongated depressions which usually have their trends parallel to mountainous coasts and chains of islands. Submarine plateaus are often found near the middle of an ocean basin, in contrast with the *continental shelf* which surrounds most continents and results from the flooding of the shallow edges of the continents by the seas.

The third order of surface features in descending size and importance on the land areas includes the mountain ridges, individual peaks, hills, tablelands, valleys, lakes, and small plains. Submarine canyons and submarine volcanoes and banks are included among the marine features affecting the contour of the sea bottom, but generally the ocean floor is more even than the land because more forces are effective in sculpturing the land areas. Both large and small land forms result from the interaction of forces that elevate or depress, build up or tear down the earth's surface. The final natural landscape that develops depends on many factors like type and hardness of rock, climate, vegetation, and other things, including the character of the original surface features.

From the human standpoint, the third order of surface features of the land areas is of more significance to most people than the vast expanses of continent or ocean basin. Relatively few people are privileged to move great distances on the face of the earth during their lifetime; millions rarely see more than the horizon of their own small plain or the confines of their mountain valley. With modern improvements in transportation, however, it

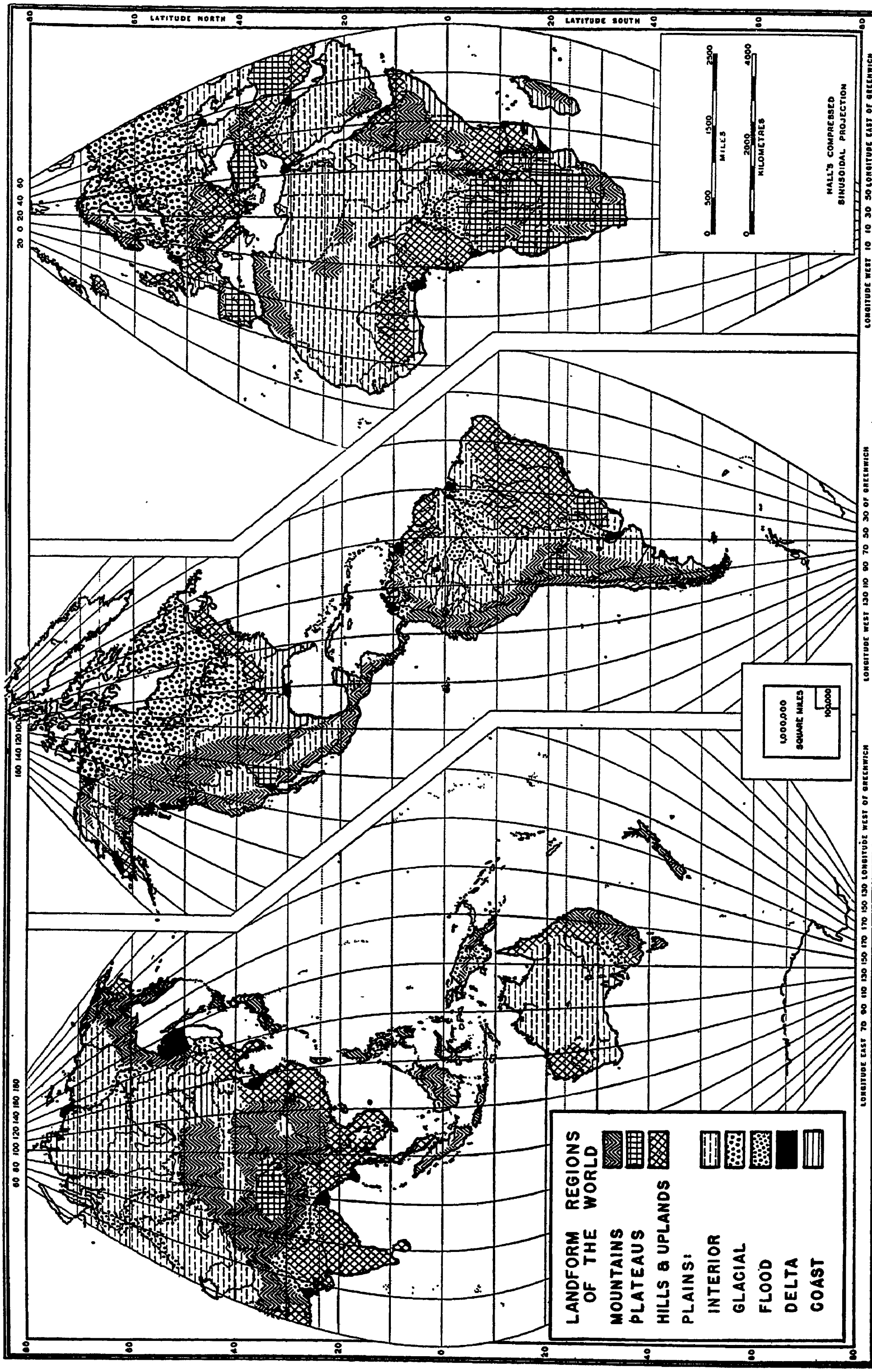

FIG. 139. Land-form regions of the world. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

becomes possible to move to distant places with little trouble or effort; and as time goes on more people become familiar with the concepts implied in terms like continent, mountain range, or ocean basin.

Conflict of Forces Affecting Land Forms. The forces originating within the earth, causing structural changes or the deformation of the earth's crust, are termed *tectonic.* They include the forces of *diastrophism,* which bend, fold, and break the earth's crust, and *vulcanism,* which supplies the molten-rock material for its surface. Tectonic forces produce inequalities on the earth's surface, such as uplifts or depressions. Earthquakes are caused by tectonic forces. The forces of *gradation* (lowering of land surfaces by erosion and gravitation) oppose the tectonic movements and tend to level off the inequalities of the land. The forces of gradation include running water, wind, glaciers, and waves. The rocks are first broken and so prepared for removal from their original position; the debris is transported and is finally deposited elsewhere. The leveling of the earth's inequalities by gradation is accomplished by *degradation* (removal of material) and *aggradation* (deposition of transported debris). These forces, both constructional and destructional, which affect earth features will be discussed in more detail later in this chapter.

Classes of Rocks. The outer few miles of the lithosphere are called the *crust* of the earth. It consists of various kinds of rocks and is quite well known to man. Little is known about the interior of the earth, on the other hand, because it has not been visited at any great depth. The rocks of the earth's crust are divided into three classes: igneous, sedimentary, and metamorphic.

Igneous rocks were once molten material; they are divided into *intrusive* and *extrusive* types, depending on the circumstances under which they solidified. The molten rocks that emerged and cooled quickly on the earth's surface, like lava and volcanic ash, are called extrusive. They have characteristics by which they may be recognized. Lava contains various gases, including water and sulphur compounds, and many gas-bubble holes, similar to those found in light bread, were left in the rock in those lavas that cooled quickly. This was true especially in the lavas that cooled rapidly at the bottom and top of the lava flow. Pumice and scoria are types of these lavas. Sometimes lava cools so quickly that it forms a natural glass, called *obsidian.* The American Indians made excellent arrowheads from such material. When some force, usually that of expanding steam, blows volcanic rocks into fine dust, the product is called *volcanic ash.* This material, thrown out by explosive eruptions of volcanoes, may be transported many miles by the winds and deposited in some distant place as a layer of soil material upon the ground.

The igneous rocks that cooled slowly far below the earth's surface are called intrusive, and their characteristics and position distinguish them from the extrusive lavas. The molten mass, or *magma,* in intrusive igneous rocks remained liquid for a long time, possibly thousands of years, because its location far underground prevented rapid loss of heat. This slow cooling gave the minerals composing the magma time to combine into granules and relatively large and definitely shaped crystals; hence intrusive igneous rock such as granite has a coarsely granular appearance. Although formed far below the surface, intrusive rocks may be exposed today on top of the ground as the result of the removal of overlying rock by natural forces of degradation.

Sedimentary rocks were formed from materials deposited in water or on land by streams, winds, glaciers, plants, or animals. Thus fine mud or clay solidified into shale; sand became sandstone; gravel formed conglomerate; limy ooze and shells made the limestone, and peat provided the raw material for coal. Because sediments are commonly deposited in beds and layers, the sedimentary rocks usually show distinct layers, or *strata,* and hence are often called *stratified rocks.*

Metamorphic rocks were once of igneous and sedimentary origin but have been changed by heat, pressure, and the deposits of material from solution; their present characteristics are therefore far different from those they first possessed. The metamorphic rocks are generally crystalline and harder than the original material of which they were formed. Thus shale, sandstone, and limestone become respectively slate, quartzite, and marble. These metamorphosed rocks not only are harder as a rule than the original sedimentary rocks, but the pressures and tensions to which the rocks have been subjected have caused the formation of many fractures or planes that permit easy splitting. This characteristic is useful in slate and permits slate shingles and blackboards to be manufactured with relatively little difficulty. *Schist* and *gneiss* are banded metamorphic rocks that have been subjected to such great changes that it is difficult to determine the original rock material with certainty. The pressure exerted upon them was so great that minerals of different types formed layers or bands at right angles to the direction of the force.

Rock Weathering. People speak of the "everlasting hills," but no rocks are so hard and resistant that they cannot be broken and worn away by natural forces. Rocks are broken and changed in character by a process called *weathering*. The weathering process is carried on by mechanical and chemical agents. Mechanical agents merely break the rocks apart or disintegrate them. Disintegration may occur after rapid changes of temperature have split the rocks by expansion and contraction. The expansion of water freezing in cracks and the expansion of growing plant roots may produce disintegration of rock masses. Boulders roll downhill by force of gravity and may be broken. Glaciers and the debris carried by running water, wind, and waves have great abrasive power. The explosive force of volcanic eruptions may shatter rock into bits. Animals and man often bring about rock disintegration by their activities.

Chemical agents actually change the substances of the rock materials, producing decay or decomposition. This may come from the solution by ground water of the cement that binds rock particles together or from the softening and crumbling of rocks when softer and looser compounds are formed from the original substances, such as the slaking of lime. Oxygen, water, and carbon dioxide are atmospheric agents for chemical weathering, subjecting the rocks to the processes of oxidation, hydration, and carbonation, respectively. Volcanic gases, humic acids from decaying organic matter, and certain bacteria are other agents causing decay of rocks. The rusting of iron is a common example of oxidation and hydration. Typical green stains on the outcrop of copper-bearing veins result from carbonation and hydration. Cracks in rock surfaces serve as convenient points of attack by both mechanical and chemical agents of weathering. Gradually the firm bedrock changes toward the surface into broken and partly decomposed fragments called *mantle rock*.

The term *soil* is applied to that part of the mantle rock of importance to plants. Soil is known as *residual* when it is formed from the weathering of the bedrock in its place of origin or as *transported* when carried and deposited by any agent. Transported soils are therefore unrelated to the underlying rock material. Soil contains humus and other organic material in addition to weathered rock and transported debris. Quantities of earthworms, nematodes, bacteria, and other living organisms affect its physical and chemical structure. The uses and character of soil types are described in Chap. 17.

Erosion

The wearing away of the rocks is called erosion. The agents of erosion include running water, glaciers, wind, and waves. These agents can pick up, transport, and deposit weathered material; and they also possess tools, consisting of stones and rock fragments,

carried by the erosive agents, through which they can abrade the exposed bedrock they reach. Material thus carried can be reduced in size by abrasion, and some of the agents are effective in sorting of debris before it is deposited. Given sufficient time, the simple processes of weathering and erosion produce profound changes on the earth's surface and may even reduce high mountain masses covering thousands of square miles to a condition geologists call a *peneplain*. As its name implies, a peneplain is almost a plain.

Stream Erosion. Running water comes from the runoff accompanying rainfall, from the melting of snowbanks and ice fields, and from springs fed by the underground water supply. When rain comes or snow melts, sheets of water creep and trickle down any slope. Soon little rills develop (Fig. 140). These lead into small gullies and then into large gullies, until finally they all join some stream which, if fed at its source by a spring, may be permanent. If there is not a permanent source, the stream will be *intermittent*.

Streams tend slowly and constantly to deepen, widen, and lengthen their valleys. The broadening and lengthening process extends first to the divides of neighboring streams, but continued modification of the resulting divides is always in progress. In doing this the running water scours material from the stream bed and undermines the banks where it is swiftest on the outside of a river bend. Clear water, however, has little power to wear away bedrock, and the actual work is done by the tools the stream carries—sand and even finer silt.

The character and structure of the bedrock have much to do with the arrangement of drainage systems. In the folded Appalachian Mountains the rivers occupy valleys that were eroded from weak rocks between parallel ridges of resistant rock material. The alternation of hard and soft rocks resulted from the folding of mountains and rocks which that region has experienced. The drainage systems that result have a *trellis* arrangement. On the Great Plains the strata lie nearly flat and are

FIG. 140. Small gullies on a plowed hillside field. Silt eroded from the slope has accumulated to form alluvial fans on a miniature scale at the mouth of each gully. The same process occurs on a large scale at the mouths of many mountain canyons. (*Photograph courtesy of the U.S. Soil Conservation Service, Department of Agriculture.*)

generally uniform in character, and as a result the river systems that develop there take on a branching pattern. This *dendritic* pattern of drainage, named for its many finger-like branches, is in strong contrast to the trellis pattern of the drainage in the folded Appalachians, where parallel ridges and valleys alternate. Dendritic drainage also is the characteristic pattern of most of the Appalachian plateaus where stratified rocks have been eroded after an uplift that only slightly deformed or warped them.

Streams transport material in suspension, in solution, and by pushing or rolling it along the stream bed. The many little whirls or eddies of water in flowing streams help the current to pick and carry rock fragments. Such material may soon be dropped, but the process is repeated and debris from the land finally reaches the ocean. Tributaries bring part of their suspended material to a main stream, particularly in times of heavy rainfall. The amount of load carried in suspension by a river mainly depends on the volume and velocity of the stream, the kind and size of weathered material available, the vegetation cover preventing soil erosion, and the character of the stream bed. Even a relatively clear stream carries some material in solution, as is evident from the residue after river water has evaporated. Large rivers like the Yangtze may carry hundreds of millions of tons of sediment into the ocean annually. The Mississippi River alone transports nearly one million tons of silt into the Gulf of Mexico each day.

Near the source of a stream many rock fragments have angular shapes, but downstream the sharp corners have been worn away and boulders are well rounded and reduced in size until the largest stones left are the size of gravel. Finally, rivers may carry only sand, silt, and clay, the larger stones having been destroyed by abrasion or left behind upstream. Boulders are moved by a process sometimes expedited by undermining of their banks by mountain torrents and by exceptional floods when running water has high velocity.

Waterfalls. Waterfalls are a factor in geography of importance for the development of water power, hydroelectric power, and the location of manufacturing plants; furthermore they limit the use of rivers for navigation purposes. Waterfalls are usually caused by outcrops of hard rock obstructing a stream (Fig. 141). Some waterfalls retreat upstream when a resistant layer of rock overlying weak rocks is eroded more rapidly, thus undermining the resistant layer and causing the falls to move headward up the stream channel. This situation prevails at Niagara Falls.

Stream Piracy. Accidental erosion by streams sometimes causes them to cut into other drainage systems flowing at higher levels. Then the upper part of the drainage of the invaded stream is diverted into the system at the lower level. This adjustment in drainage is called *stream piracy,* and such changes are constantly in process of development. Some have occurred so recently that a lake or river drains in two directions. In Yellowstone Park, for example, a small pond known as Two Ocean Lake occupies a location on the Continental Divide, and its overflow goes into streams that eventually reach both the Atlantic and Pacific oceans. The Shari River in north equatorial Africa drains during floods into the closed basin of Lake Chad and also into the Niger River and thence to the Atlantic Ocean. In North America most of the portages used by the fur traders in their journeys between the Great Lakes and the Ohio and Mississippi rivers follow abandoned waterways. In Europe the canals connecting the rivers of Germany crossing the northern plain are often built along similar deserted river channels.

Cycles of Erosion. Rivers tend to erode their beds to a base level determined by the level of the body of water into which they flow, or temporarily by a ledge of resistant rock or other obstruction. When rivers have attained base level, their courses show smooth profiles that lack falls or rapids. It should be mentioned, however, that different sections

FIG. 141. Lower falls of the Yellowstone River, 308 feet high. The canyon is eroded in a high plateau of lava which covers most of Yellowstone Park. The location of the falls is determined by the presence of a dike of resistant rock material. These falls have been preserved for their scenic value, but they could have been used to generate electric power. (*Photograph courtesy of the Northern Pacific Railway.*)

along a stream may have different base levels and that those parts of the river at grade may be separated by swift portions that have not yet reached base level. The final base level is determined by the level of the oceans.

Rivers and the regions they drain pass through cycles of erosion, with distinct characteristics for youth, then maturity, and finally old age. In *youth,* streams have only begun their work (Fig. 142-A). Their basins as a whole have many undrained areas such as lakes and swamps. The divides between streams are broad and little eroded. Youthful streams occupy steep-sided V-shaped valleys in which rapids, waterfalls, and lakes may occur. The streams are swift, having rather straight courses, and are actively cutting down their beds.

In *maturity,* rivers and their tributaries have eroded headward (upstream) until the whole region is well drained and completely dissected. Little of the original upland remains; hence the stream divides tend to be narrow (Fig. 142-C). Mature streams have nearly attained base level. Their rapids are fewer than in youth, and waterfalls and lakes have nearly disappeared. Valleys are broad, with gentler slopes than in youth. The rivers have begun to *meander* (flow in great curves) and to develop valley flats or flooded plains (Fig. 143-A). The flood plain is covered during high water, hence the name, and is formed partly by undercutting on the outside of bends and partly from deposition on the inside of meanders.

In *old age,* streams have reached base level. Their valleys are very broad, and divides have been so reduced by erosion that the region has become a peneplain (Fig. 142-D). As valleys widened and divides lowered, streams were absorbed and consolidated, and the number of rivers became fewer. A few rem-

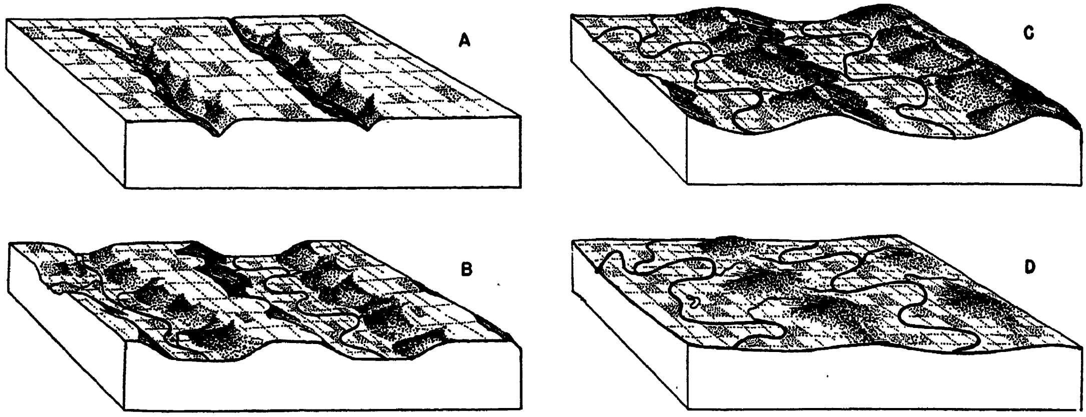

FIG. 142. Evolution of a landscape through four stages of its degradation by natural agencies.

A. Condition of low relief with a landscape composed largely of wide interstream spaces. Active erosion and trenching is under way by relatively small but effective streams. Stream terraces and flood plains are small or nonexistent. Special soil conservation methods are essential if wide expanses of cultivable land are to be maintained successfully. This is an example of a region in a condition of youthful land forms.

B. Moderately advanced relief of the land, in early maturity, with marked destruction of the upland surfaces shown in *A* and some development of depositional terraces. The stream at the right has widened its valley noticeably and has begun to meander as its gradient is reduced. Bottom lands as well as upland can be tilled, but the bottoms will require the construction of expensive flood control devices.

C. Advanced state of mature landscape with pronounced stream meanders, sluggish stream flow, and small remnants of the formerly extensive upland seen in *A*. Each stream is encroaching upon the drainage area of the other. Flood danger is greater than in *B*, and control measures are essential.

D. The landscape has returned to a condition of low relief or old age as the result of the natural forces which are shaping it. The uplands of *A* have been destroyed, and only island-like remnants, called monadnocks, indicate the presence of the former upland. Stream meanders swing widely in the flood plains, and drainage and flood protection of the lowland will be needed before farming can be successful.

nants of erosion, rounded hills of the most resistant rock, called *monadnocks,* may rise above the plain. Old-age rivers carry more material in solution than in suspension. They meander widely across the plain, and "oxbow" cutoffs or lakes (Fig. 143-B) occur where the current in flood has cut through the narrow neck between two curves. The rivers are sluggish, but they drain the entire region.

Deposition of Load. Streams deposit their load of sediment whenever decreased velocity or declining volume of flow lessens their capacity to carry material. Such deposits frequently are made at the bases of slopes, along river courses, and at the mouths of rivers. Running water thoroughly sorts the debris it carries. The largest and heaviest stones are dropped first, followed in order by gravel, sand, and mud.

Deposition at Bases of Slopes. When a heavily loaded stream has its capacity to carry material in suspension suddenly reduced, as when its velocity is reduced by lessening of slope, conditions for deposition are favorable. Thus *alluvial cones,* or *fans,* of coarse debris are deposited at the mouths of hillside gullies where they debouch to gentler slopes (Fig. 140). Mountain torrents also experience a sudden change in slope where they leave the mountains and flow out on broad plains. This reduces the carrying power of floodwaters; and the streams are forced to deposit great fans, which frequently coalesce to form compound alluvial fans or slopes, sometimes called *alluvial piedmonts* because of their location at the foot of mountains. Where coarse material predominates on these piedmonts and fans it is unsuited for crops, but

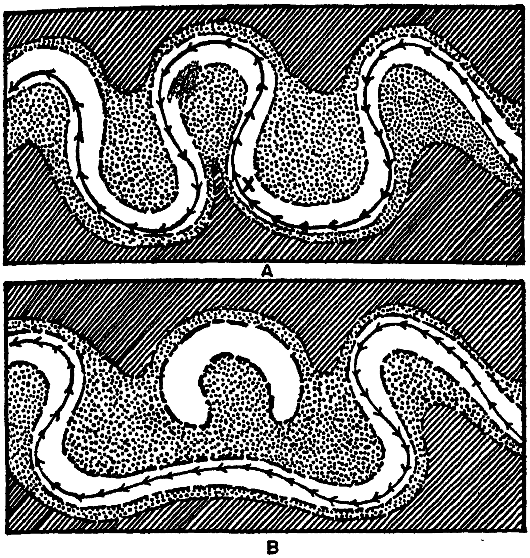

FIG. 143. Stream meanders and an oxbow lake. *A*. The stream has reached a stage of maturity in which it flows almost at grade. Large swinging meanders have developed in its flood plain, and the neck of the middle meander is nearly cut through by the undercutting of the current at *X*. *B*. Here the stream channel has been straightened naturally. The current has cut through the neck at *X*, leaving the former channel as a semicircular oxbow lake detached from the main channel.

the fine material makes excellent farm land (Fig. 144). The sediments of alluvial fans change rapidly as to size of material, and their strata are often cross-bedded. Shifting currents, to be expected where torrential fans are being deposited, cause sudden changes in the direction and inclination of the layers of debris, and this is known as *cross-bedding*.

Deposition along Rivers. Deposits are made along rivers carrying material in suspension wherever the velocity of the stream decreases. The resulting mudbanks and bars of gravel and sand are located in quiet water in the lee of some obstruction, on the outside of meanders, or along the banks of streams during floods. On a flood plain the banks may be built higher than the surface distant from the stream to form *natural levees*. Sometimes a river becomes so overloaded with sediment that the material is deposited in the stream bed itself, clogging the channel and forming a "braided" stream of many shifting channels (Fig. 145), like the channel of the Platte River. The deposits thus laid down are cross-bedded because of the shifting currents. The streams depositing debris in their beds are said to be *aggrading*, in contrast to the normal condition in which a river is *degrading* (lowering) its valley by erosion.

Deposition near the Mouths of Rivers. Deltas occur at river mouths when streams carrying much sediment flow into quiet bodies of water and are forced to deposit their loads because their stream velocity is suddenly checked. If strong tides or currents are present, however, the deposits are distributed alongshore or are carried into deep water, and no delta is formed. Sediments deposited in quiet water form nearly level strata in contrast to the cross-bedded deposits common farther upstream. In a delta the deposition of material in the stream bed causes the river channel to divide. By repetition of the process, numerous *distributaries* fed from the main river are formed in the delta, and the channels constantly shift as deposits are made, making the lower delta regions somewhat difficult for occupance. Often in a delta it is difficult to tell which is land and which are water surfaces.

Some Special Features Observed in Valleys. If a broad-floored valley of depositional or erosional origin is elevated, or if its stream for any reason renews its downward cutting, it would be clear that remnants of the old flat would remain above the new valley floor. These flat areas, records of higher last levels of a river, are called *river terraces*. If a stream has cut through a mountain ridge, the resulting gorge is termed a *water gap*, or narrows. Occasionally drainage changes leave an abandoned water gap; the pass that remains is called a *wind gap*. After a river has developed a meandering course across a flood plain, an uplift of the land may force the stream to renew downcutting in its bed, producing the phenomenon of entrenched meanders. Meanders are considered characteristic of late maturity or old age, but when they have

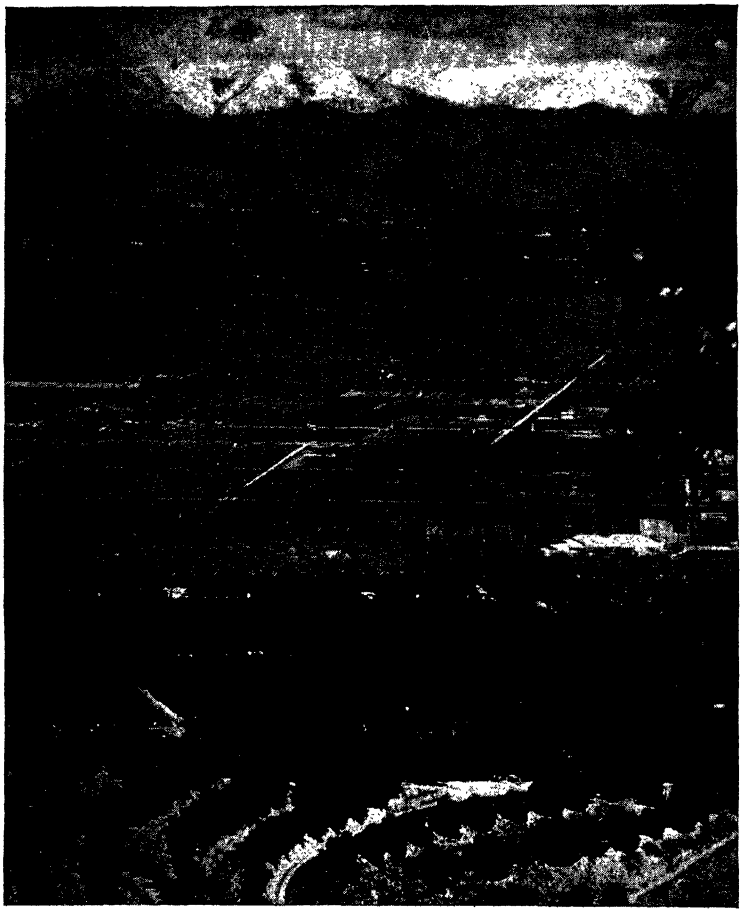

FIG. 144. Typical southern California view, showing the crop zoning of the alluvial piedmont at the base of the San Gabriel Mountains. View toward the north, with the snow-covered mountain range, topped by an ancient peneplain surface, forming the sky line. At the foot of the mountains the orange and lemon groves descend to the lowlands, where the dark trees are replaced by the bare limbs of deciduous fruit trees and vineyards in the middle distance. In the foreground slope, crop zoning is repeated, with the lower edge of the citrus grove sharply delimited by low temperatures. Contour irrigation and planting of orange trees in the immediate foreground. (*Photograph courtesy of the Los Angeles County Chamber of Commerce.*)

become incised in narrow youthful valleys as described, the region and the stream are said to have been *rejuvenated.*

Nomenclature of Surface Features. Various names, taken from different languages, are used in English to describe and name earth features. Some have been invented to fill a need, the words erosion and peneplain being good examples. In other cases the name of a specific example of a phenomenon or principle is used for the general term. Meander is the name of a twisting river in Asia Minor and monadnock the name of a mountain in New England that has resisted erosion and stands above an old peneplain surface. Dozens of names have been used for flowing water, including river, stream, riverlet, rivulet, channel, rill, creek, fork, brook, run, or wash; and for valleys, gorge, canyon, coulee, wadi, ravine, gully, vale, dale, dell, swale, gap, pass, glade, glen, trench, rift, graben, and arroyo are among the numerous examples.

Elevations on the land likewise bear many names, among which are mountain, peak,

FIG. 145. Stewart, British Columbia, a small isolated settlement located on the delta of a braided stream that enters the head of a fiord. This town is almost wholly lacking in productive hinterland. (*Air Force photograph.*)

ridge, hill, butte, tableland, plateau, mesa, hogback, cuesta, terrace, bench, height, summit, tower, pillar, precipice, pali, escarpment, cliff, bluff, crag, ledge, knoll, mound, dune, alp, hillock, hummock, and kopje. Different names are used in different parts of the world; for example, in the western United States where Spanish names are common, large tablelands are termed mesas, isolated hills are called buttes, and extensive areas of gently inclined strata, protected by a hard capping and ending in a cliff, are given the name of *cuestas* by geologists. The Niagara escarpment over which the Niagara River falls is the edge of a cuesta. English words are used for the situation where erosion cutting into horizontal bedded rocks of varying hardness forms rock terraces on the outcrop of the resistant layer and where steeply dipping rocks are eroded to form narrow-tipped ridges called *hogbacks* (Fig. 165). Some words are in local use only; pali, meaning cliff, is used in Hawaii, and kopje, meaning butte, is used in South Africa.

The Work of Wind. In dry climates where there is little vegetation and moisture to hold the soil, winds become important agents of erosion and may cause the soil to blow and drift. Careless farming methods and overgrazing by livestock may destroy the grass cover protecting the ground and allow the wind to do great damage to the soil. The topsoil from whole farms has moved with the wind during a single dust storm on the Great Plains (Fig. 106). Wind-blown sand hurled against rock cliffs removes the weaker portions and etches the most resistant parts into relief. Mushroom-shaped rocks commonly result from wind erosion (Fig. 146).

Sand may be blown into heaps or dunes by the wind. The material for dunes may come from the weathering of sandstone or other suitable bedrock, but more commonly it is brought in by temporary floods and streams.

Fig. 146. Mushroom rock in Death Valley, California, formed by a combination of rock weathering and wind erosion. Desert landscapes of this type are almost entirely lacking in vegetation throughout most of the year. (*Photograph by Frashers Photos, Pomona, California.*)

Sand for dunes is also left on the shore by rivers and by the waves of lakes or oceans. When dry, the sand is subject to the work of the winds, and dunes begin to form, especially to leeward of obstructions. Once started, sand dunes move in the direction of prevailing winds and sometimes bury forests, fields, and houses in their paths. The control of moving dunes is difficult and is best accomplished by plants, especially those with creeping roots, which cover, protect from the wind, and bind together the moving particles. Sand dunes are widely distributed in deserts but are common also along seacoasts and the shores of large lakes in quite humid regions like the Gulf Coast and Lake Michigan shore line. Sand grains in dunes are well rounded from mutual abrasion resulting from their movement by the wind. Ripple marks made by wind generally mark the surface of dunes. If wind-deposited sand later becomes solid rock, the rock shows cross-bedding similar to that made by swift-running water because winds, like stream currents, shift their directions from time to time.

Dust in great quantities may be blown from deserts and dry steppes by strong winds. Where the winds are prevalently in one direction, the dust is dropped to leeward of the deserts in regions having sufficient rainfall to support a good growth of grass. The grass prevents the wind from moving the particles again, and the dust accumulates. These dust deposits, called *loess,* are particularly important in China east of The Gobi, on parts of the Columbia Basin, and in the lower Missouri Valley. Some so-called loess in humid regions may have been deposited by running water. Loess soils are inherently fertile; but, once the sod of semiarid grasslands is broken, cultivation must be done carefully, or drifting of the soil by the winds will occur in dry years. During the 1930's, damage was done in parts of the Great Plains by giant dust storms that moved millions of tons of fine material. The control of drifting soil is best accom-

plished by planting certain fodder crops and reestablishing a cover of grass, although tillage methods have been developed that minimize soil movement.

Winds carrying sand may abrade, erode, and polish boulders and exposures of bedrock. The faces of cliffs are sometimes pitted by the effect of wind-blown sand, and stones may be beveled and polished by the same action. Glass in exposed lighthouses has had to be replaced because of the grinding of the natural sandblast.

Ground Water. The term *ground water* refers to the water underground, which is derived mainly from the rain that sinks into the earth. The amount of this "sink off" depends largely on the slope, the character of soil and bedrock, the natural vegetation, the crops, and the methods of cultivation. It is also affected by the quantity and character of rainfall, since the water of a long gentle rain may sink in while that of a cloudburst may nearly all run off. Water that is held near the surface of the ground in the tiny openings or capillary spaces between soil grains and rock particles is utilized by plants. Its conservation in semiarid climates is highly important to farmers. In dry-land farming the surface cracks and capillary tubes through which the precious moisture evaporates are broken by cultivation. This covers the ground with a clod and dust mulch that interferes with the escape of water, thereby retaining needed moisture in the ground for the use of crops. A rough cloddy surface is now recommended to "dry farmers," since a fine dust mulch allows the soil to blow too easily.

Rain water that sinks below the surface soil continues until it is impeded by some impervious earth or rock (Fig. 147). Above this, the small openings in the pervious material are impregnated with water. The upper level to which these openings are filled is called the *water table*. Wells dug or drilled below the water table reach a permanent supply of water; and if a valley has been eroded

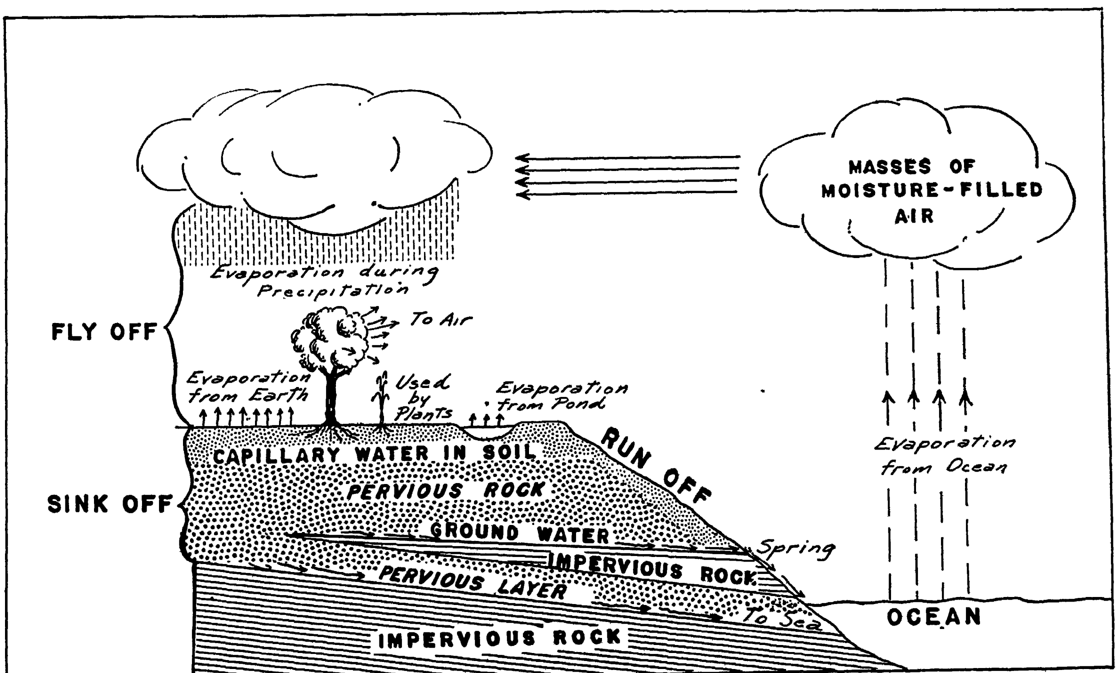

FIG. 147. Normal movement of moisture on the earth's surface. Moisture is returned to the sea by both underground and surface flow; then it is evaporated into the air, returned to the land by air movements, and precipitated over land.

to this depth, seeps and springs result. On a hillside the common location for springs is determined by the outcrop of an impervious bed or rock above which water is retained until it can slowly seep out. Simple natural conditions also account for artesian wells. Here a pervious stratum, like gravel or sandstone, between two impervious beds is exposed at some high elevation where water seeps into it. The impervious beds of rock hold the water under pressure in the pervious material. When the pervious stratum is tapped by a drilled well whose outlet lies below the water level in that stratum, a flow of artesian water results. If the well outlet is higher up the slope, however, the water may rise only part way to the surface. A natural orifice leading from the underground supply may feed a large spring of steady flow, unaffected by drought years that would dry up an ordinary hillside spring. Springs and artesian water supplies are important factors in the location of homes and towns in regions of water scarcity. In Queensland, Australia, the Great Artesian Basin supplies water to thousands of stock ranches that depend upon this subterranean supply.

When ground water percolates through soil and rocks, it may dissolve and carry away considerable amounts of soluble minerals. Limestone is soluble in water containing carbon dioxide, a gas derived from decaying organic matter. This carbonated water seeping through cracks in limestone enlarges the openings until large caves are formed. Water dripping into these caverns may evaporate and deposit its dissolved limestone, forming the beautiful icicle-like stalactites on the roof of the cave, bulbous stalagmites on the floor, and other deposits (Fig. 148). Springs sometimes deposit lime, iron, and other compounds at the surface, while cracks in rocks are often filled with minerals deposited by

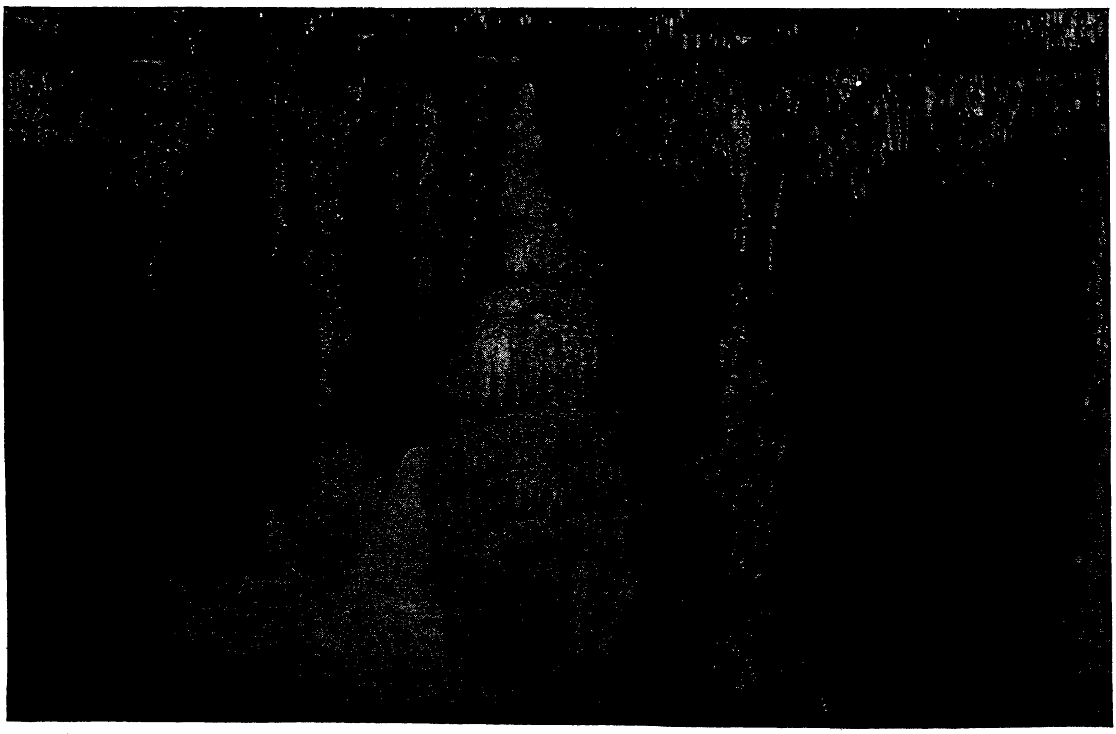

FIG. 148. Stalactites and stalagmites in Marengo Cave, Crawford County, Indiana. These formations are made by the slow deposition of mineralized water as it seeps through the roof of the cavern and drips to the floor.

ground water. The rich veins and ore pockets in most mines were formed in this way.

Geysers, spouting hot springs that erupt at intervals, occur abroad in Iceland and New Zealand. Notable geysers are formed in Yellowstone Park, where they are a major tourist attraction.

Glaciers. Glaciers consist of moving masses of ice formed on land from the consolidation of snow. They are agents of degradation in high mountains of mid-latitudes, and they even descend to sea level in snowy regions like the coast of Alaska and from cold plateaus like Greenland and Antarctica. In the past continental glaciers covered North America well into the United States and extended over the whole of northwestern Europe and parts of Siberia (Fig. 139). Glaciers develop where snowfall exceeds the rate of melting and evaporation. By pressure, partial melting, and refreezing, snow is transformed into ice. When the ice has movement, it becomes a glacier. Glaciers move down slopes and outward from their source until melting equals their rate of advance. They move from a fraction of an inch to many feet per day and secure debris from their beds and cliffs around them. This material is dropped when the ice melts. The surface of glaciers is often covered with rocks that are exposed when the snow and ice melt. Crevasses in the ice occur as the result of movement over irregularities and enlargement of the cracks by melting. Melting takes place all through a glacier; some melt water runs off from the upper surface, and some collects beneath the ice, emerging from a tunnel at the lower end of the glacier in the form of a large river. The water of glacier-fed rivers has a milky appearance from its load of silt (Fig. 145), which it obtains by pulverizing the rock and forming *rock flour.*

Continental glaciers changed the whole appearance of the northern United States. In New England and in those states bordering the Great Lakes, they covered the land with debris called *drift. Glacial drift* consists of unassorted debris called *till* and the glaciofluvial material deposited by the glacial melt water. Glaciofluvial deposits may be sorted and even stratified. Glacial till consists of rock flour, large and small boulders, and rock debris of all types dumped together at random. Great volumes of glacial melt water sorted, transported, and redeposited some of the material from the end of the melting ice. These glacial floodwaters deposited the reworked material to form *outwash plains* in front of continental ice sheets, thereby providing a convenient source of commercial supplies of glacial sands and gravels which are much used for concrete and other construction work.

Glaciers of continental extent secured most of their load from local sources, though they also carried some boulders from distances of hundreds of miles from Canada. In New England and northern Wisconsin, where the bedrock is hard, the glacial till is very stony, and cultivation of the soil is difficult; but around the lower Great Lakes the till was largely derived from weak easily weathered rock, and the land is easier to plow and develop into farms. Shallow glacial lakes soon filled with peat and silt and became some of the swamps that are characteristic of glacial plains. The continental ice sheet often interfered with drainage and formed temporary lakes in which layers of silt and clay were deposited. Some of the swamps and glacial lake beds when drained have made very fertile and productive farm land (Fig. 149), but some of the former lake beds are sandy and of limited use, like that of former Glacial Lake Wisconsin. Among useful examples are extinct glacial lakes in Ohio, whose beds are referred to as "muck land," and usually their commercial value is far higher than that of adjoining farm land, for they are capable of producing several crops each summer and provide eastern cities with some of their best supplies of celery, root crops, spinach, and other high-value truck crops.

Glaciers created thousands of these lakes, the largest of which are the Great Lakes, possibly in part formed by glacial erosion of

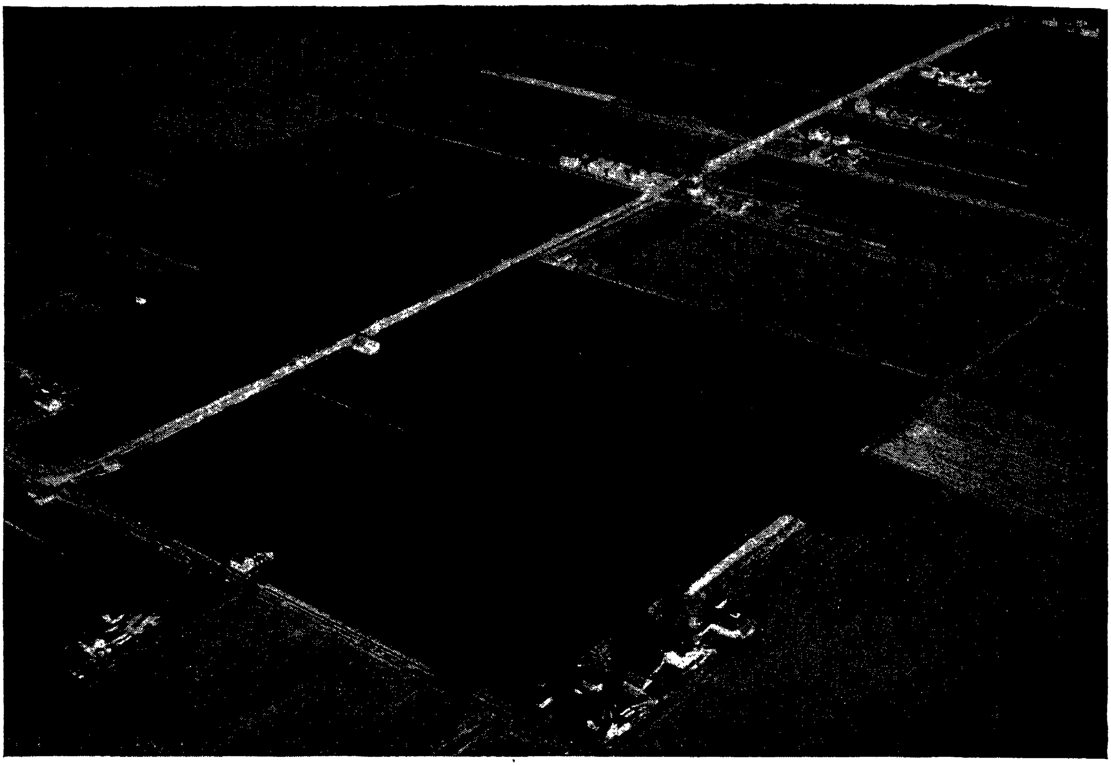

Fig. 149. Valuable farm lands near Hartville, Ohio, on which several crops of celery, spinach, radishes, and other garden vegetables may be grown commercially each season. This level plain formerly was a glacial swamp in which the soils were mucky. The swamp vegetation was cleared, the land was drained, and became highly productive. Note the rectangular field pattern and the dispersed habitations that are characteristic of large parts of America's farm lands.

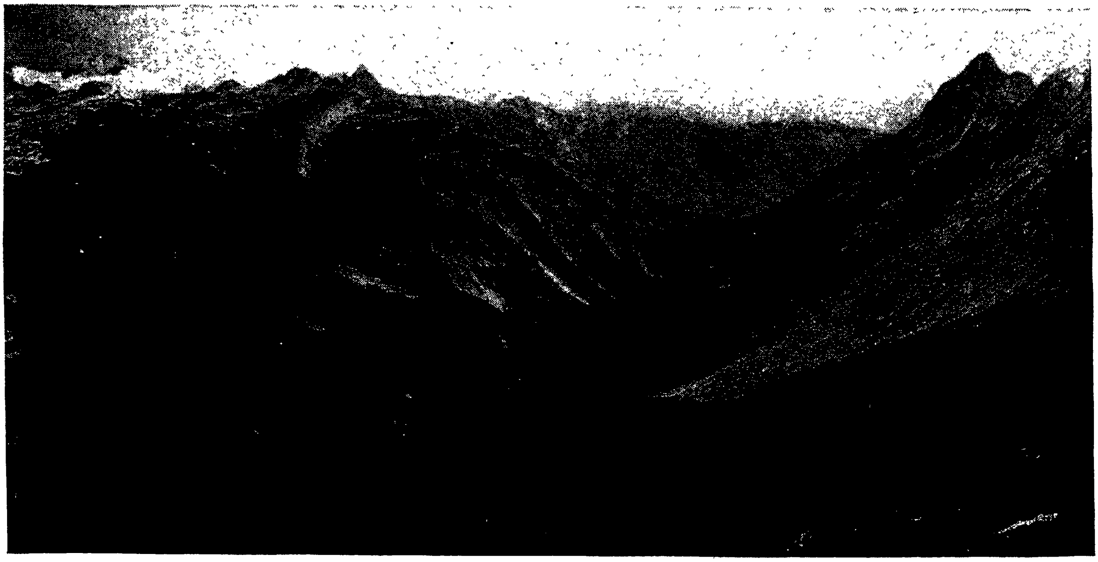

Fig. 150. The form of this U-shaped valley in the northern Cascade Range has been changed by glacial scouring of a deep river canyon. The moving ice wore down the ends of projecting ridges, deepened and broadened the valley, and smoothed and polished the bedrock, greatly modifying the original appearance of the valley. (*Photograph by Lindsley.*)

weak rocks. The courses of rivers were changed and reversed; waterfalls, cascades, and rapids like those at Niagara were formed; and the present utilization of the land by man was profoundly influenced. In places glaciers made hilly regions more level by planing off hilltops and filling valleys; this was particularly the case in northeastern Ohio where the hilly lands of the Appalachian Plateaus were leveled by the action of the continental glacier and its deposits. Elsewhere great heaps of debris called *moraines* were laid down by the ice. These moraines were sometimes hundreds of miles long, with hummocky, irregular surfaces often covered with enormous boulders.

Mountain glaciers also were much more extensive several thousand years ago than they are now. They planed off the ends of ridges and smoothed the valley sides, changing the normal V-shaped valleys of erosion on mountain slopes into broad U-shaped valleys (Fig. 150). Main valleys occupied by ice were overdeepened and widened, leaving former stream tributaries "hanging" well up on the side slopes. Waterfalls like Yosemite often plunge from these hanging valleys. Glaciers work headward at their sources and often excavate the valley there into a steep-walled semicircular amphitheater, or cirque. Glaciers sometimes gouge the bed of the cirque irregularly, leaving depressions in the bedrock which subsequently may be occupied by rock-basin lakes (Fig. 151). Farther down their valleys, glaciers usually deposit large terminal moraines. These dams often impound beautiful

FIG. 151. Lake Ellen Wilson, in the northern Rocky Mountains. This glacially formed lake occupies the valley of a former active glacier; the ancient cirque appears in the distance. (*Photograph courtesy of Glacier National Park authorities and the National Park Service of the Department of the Interior.*)

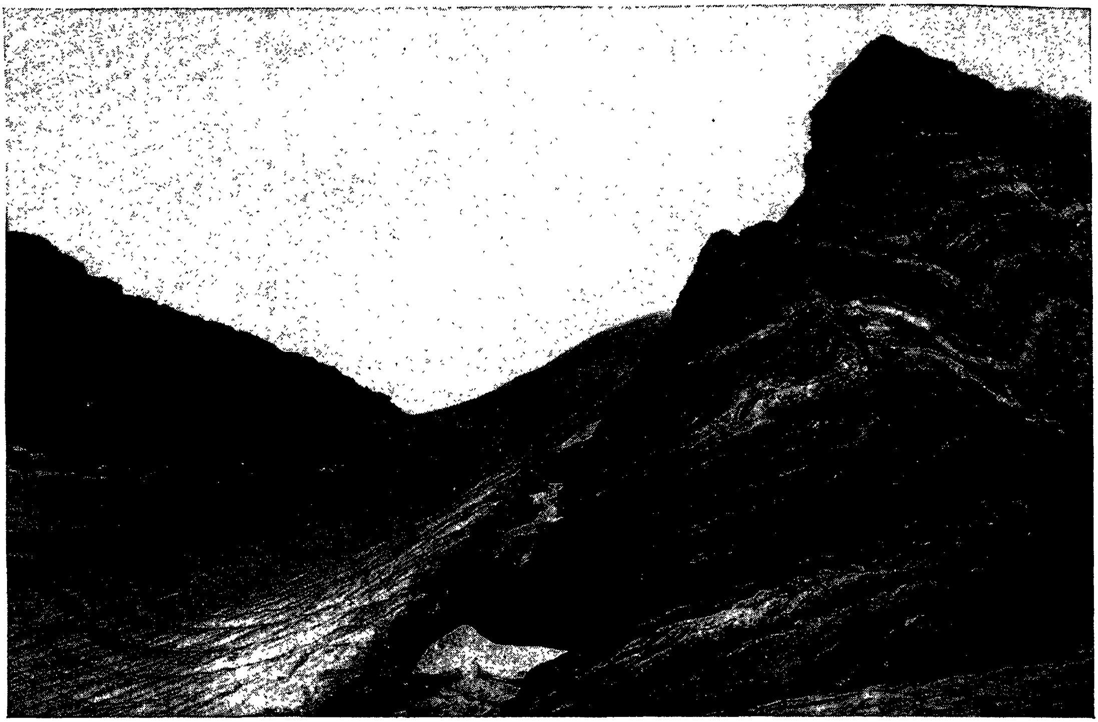

FIG. 152. Sperry Glacier in Glacier National Park occupies a cirque. The lines crossing the ice indicate that the glacier moves more rapidly at the center than at the sides. Note how the rock sediments at the right of the picture have been crumpled, twisted, and mashed together by the enormous pressure exerted when the mountains were being formed. Small faults can be seen on the face of the cliff at the right. A lateral moraine appears at the side of the ice in the lower left corner. (*Photograph by Hileman, courtesy of the Great Northern Railway.*)

mountain lakes. Deposits along the sides of the glaciers, including those on the ice itself, are known as *lateral moraines* (Fig. 152); and if two are joined they form a *medial moraine.*

Waves and Currents. In oceans and lakes, waves and currents concentrate their work along the shores and in narrow channels. Locally they are important as agents of erosion. Erosion is accomplished by sand and stones carried by the water, not in the open sea where only the wave form moves forward, but in shallow waters where the base of each wave is slowed by friction and the top breaks forward, hurling the water upon the shore. The returning water forms an undertow which carries much material away from the shore. The constant motion of the water along the shore line causes the sand and stones to rub together, quickly rounding angular fragments and ultimately wearing away even the hardest materials. Wave erosion proceeds most actively on exposed islands and headlands and is particularly rapid on some coasts (Fig. 153). At Cape Cod and along the chalk cliffs of England, the shore line retreats several feet each year from attack by waves. It has been estimated that the southern shore of Lake Erie has retreated on the average about 6 feet each year under the wave battering it experiences during storm periods. Wave erosion develops steep cliffs and in bedrock erodes picturesque wave-carved caves and arches. *Stacks,* or chimney-like rocks, are left offshore as the shore line retreats. Along protected coves, across the entrances of calm bays, and in quiet waters generally, the longshore currents tend to deposit material eroded from exposed locations. Offshore bars develop where storm waves break along low-lying coasts. Most of the coastal erosion is accomplished by the large

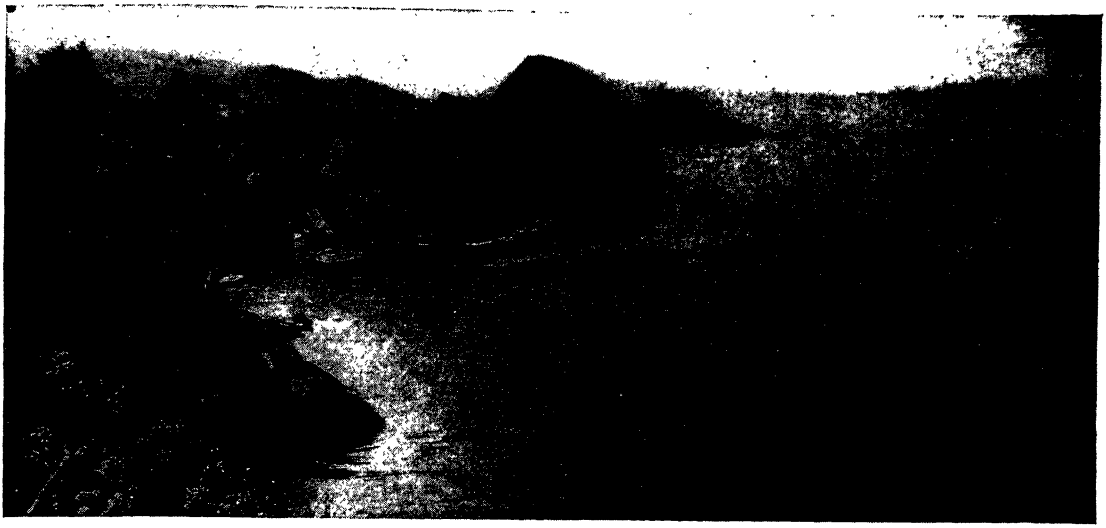

FIG. 153. Wave erosion along the emergent coast of Oregon has produced these steep wave-cut cliffs and rocky isolated stacks offshore. The waves have carved a sea cave through the point at left center. An older wave-cut terrace is visible in the form of the level ground at the top of the present cliffs.

waves and high waters that accompany severe storms. The net effect of waves and currents is to destroy projections along the coast and deposit some of the material in calm waters between headlands.

Deposits made along coasts add to the work of erosion in modifying coast lines. Wave deposition may leave beautiful curving sandy beaches that are attractive to many people during the warm season. Waves sort material well, leaving boulders on the beaches in swift waters; "shingle" in less swift water; then sand, and finally mud. Offshore the same sorting action occurs. Hence near the coast the moving water drops the coarse material, farther out the sand, then the mud and silt; and finally the smallest particles of limy ooze reach the ocean floor. When these sorted materials become consolidated into solid rock, the sedimentary rocks—conglomerate, sandstone, shale, and limestone—are formed in that order outward from the shore. The combined effect of erosion and deposition along coasts is to develop a gentle slope partly above and partly below the usual sea level. If the land then rises relative to the sea, the old nearly level sea bottom becomes an ocean terrace.

Diastrophism

The term diastrophism (movements in the earth's crust) has been applied by geologists to the processes of mountain building, rock folding, earthquakes, and uplift and downwarping in general. All land surfaces would be reduced by denudation to peneplains and wave action would truncate the last land above sea level until the whole world would be covered with a water surface if it were not for other forces that counteract the results of erosion. Various forces, however, do elevate parts of the earth's crust and thereby offset the work of weathering and erosion. High mountains, broad plateaus, and extensive plains result from the slow action of internal forces that heave up large land masses. Since geologic time includes millions of years, there is sufficient time for these profound changes to occur.

Earth Movements. When compressive forces develop in the earth, owing to contraction of our globe or some other cause, they exert the

greatest effects where the earth's crust is weakest. Zones of weakness may develop in the interior of land masses but are most common along the edges of continents where thick beds of sediments have collected. Here compression may crush the sediments together, fold them into high mountains, and sometimes produce breaks, or faults, in the earth's crust. Thus rugged mountain ranges frequently parallel coast lines. Movements along fault lines cause most of the earthquakes. Sometimes volcanoes break out along the fault zones. The Pacific Ocean is nearly surrounded by rugged chains of mountains with numerous volcanoes, from the southern tip of South America through North America via the Aleutian Islands to Kamchatka and Japan, and thence through volcanic and mountainous islands to New Zealand. In addition to uplifts of the land, sinking of blocks of the earth's crust also occurs.

Sea shells and marine fossils that have been found far inland and even near the summits of high mountains are evidence of the uplift of land. Further evidence of uplift appears in beaches, terraces, wave-cut cliffs, and other coastal phenomena clearly visible high above the ocean along rising coasts like the Pacific coast of North and South America. On the other hand, the sinking of the land has caused the "drowning" of rivers, changing them to widemouthed estuaries in which trees and man-made structures have sometimes been submerged. Changes of level in the interior of continents have taken place frequently but are less evident than along the coasts.

Earthquakes. Earthquakes may accompany volcanic eruptions, but more often they result from strong earth stresses that crush, bend, or break the rocks. The movements of rocks underground, usually for only a slight distance, cause vibrations of the earth which are transmitted to the outer crust. Most earthquakes can be detected only by a delicate instrument called the *seismograph,* but occasionally severe shocks occur which cause much loss of life and property and which produce important changes on the earth's surface. It should be noted that the earthquake does not make a fault or break in the rocks but is itself the result of such movement. From the earthquake focus, or place of occurrence, compression waves pass outward in all directions. Some waves pass along the crust of the earth, others through the interior directly from the focus. The speed and character of earthquake waves depend on the density and elasticity of the material transmitting the vibrations. By a comparison of the time of arrival of two sets of waves at a seismograph, the approximate distance to the source of the earthquake and sometimes its depth can be calculated. The term *seismic* is used to refer to earthquake phenomena. Seismic areas of the world are shown in Fig. 154.

Earthquakes may be very damaging to life and property if they affect well-populated areas, especially cities. Regions of active mountain uplift are most apt to have earthquakes, although probably no part of the earth's surface can be considered entirely free of seismic danger. In Europe the island of Sicily and the southern part of the Italian peninsula have been most afflicted with earthquakes. In 1783 over 30,000 people perished in this region; again in 1908 a terrible shock destroyed the city of Messina, killing over 76,000 persons. Japan, interior China, India, Chile, Central America, and southern California are other regions where earthquakes have occurred with some frequency. Noteworthy earthquakes killed several hundred thousand people in Kansu and Shansi provinces in China in December, 1920, and destroyed Lisbon, Portugal, in 1755. Japan was afflicted in 1703, 1858, 1896, and in 1923, when some hundreds of thousands were killed or injured at Tokyo and Yokohama. In the United States a movement along the San Andreas fault in 1906 did much damage at San Francisco and in that vicinity.

Earthquakes sometimes occur far from mountains, as at New Madrid in southeastern Missouri in 1811 and at Charleston, South Carolina, in 1886. Earthquakes at sea or close

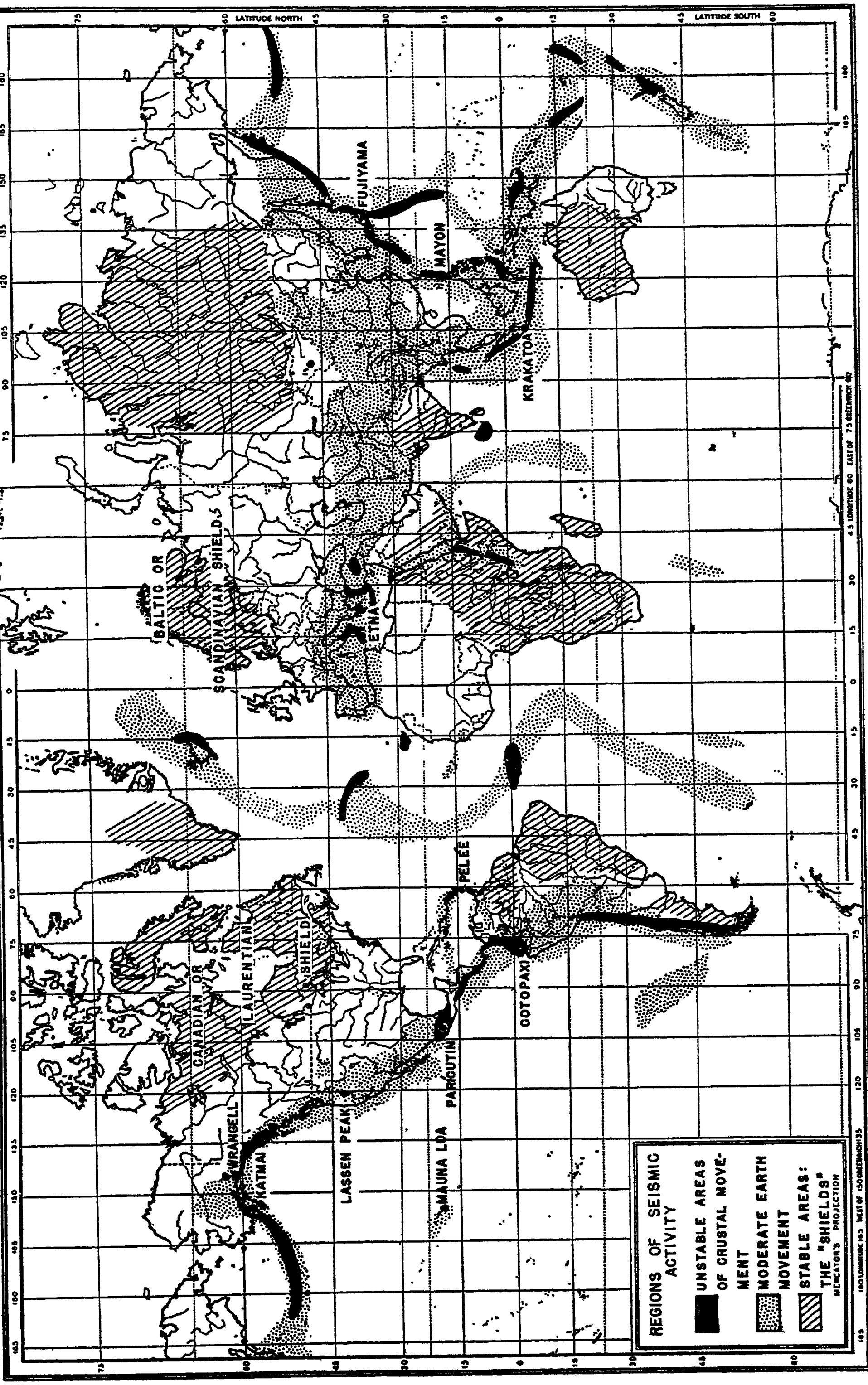

FIG. 154. Regions of seismic activity. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

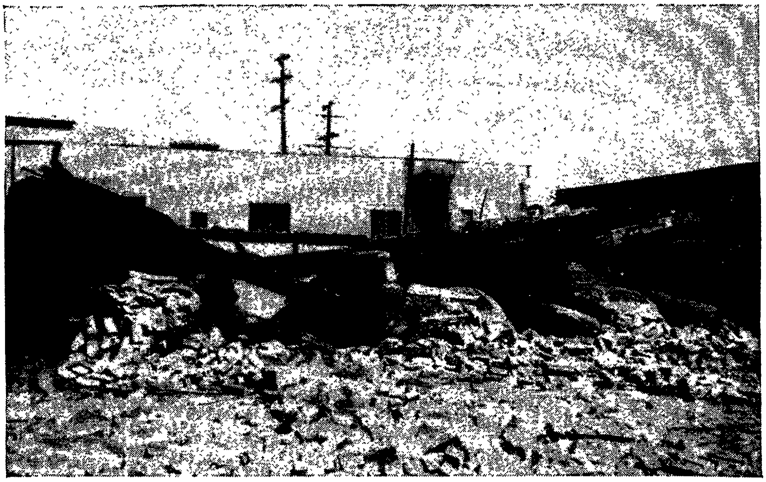

FIG. 155. Effects of an earthquake on poorly constructed buildings at Brawley, California.

to shore may produce high, misnamed "tidal" waves that drown many persons and damage shipping and longshore property. Earthquake damage depends a great deal on the type of building construction in the afflicted area. At Long Beach, California, in 1933, and later at Brawley, only poorly constructed buildings were seriously damaged by a fairly severe quake (Fig. 155). Solid stone and brick structures are easily destroyed while frame buildings, if properly tied together, resist earthquakes very well, as do structures of reinforced concrete and steel. Buildings can be constructed in such a way that they will resist earthquake damage, and this should always be done in regions where shocks may be expected. City buildings should be as nearly as possible of fireproof construction, since fire accounts for much of the loss of life and property, as at Tokyo in 1923. In cities emergency reservoirs should be built to provide water for fire protection and domestic supply if the pipes bringing water happen to be broken by the quake, as at San Francisco in 1906, when the fire following the earthquake destroyed more property than the quake itself.

Vulcanism

Volcanoes. Like earthquakes, volcanoes occur along lines of weakness in the earth's crust; some well-known volcanoes are shown in Fig. 154. From a geologic standpoint vulcanism produces swift changes of the earth's surface. The ultimate source of magma (molten rock) probably lies many miles beneath the surface of the earth, and the exact cause of the formation of the magma is uncertain. Single eruptions have formed cinder cones hundreds of feet high. Paricutín in Mexico first erupted in a cornfield in 1943, and within 2 years it had attained an altitude greater than 1,000 feet and had destroyed several villages and many farms.

Some of the world's most active volcanoes are in the Aleutian Islands. One of these is Pavlof, which has had major eruptions in 1910, 1911, 1914, 1917, 1922, 1923, 1924, 1929, 1931, 1936, 1937, 1942, and 1945. Another is Shishaldin, nearly 10,000 feet in elevation, with great eruptions in 1901, 1912, 1922, 1925, 1928, 1929, 1932, and 1946. In Italy, Vesuvius experienced great eruptions in 1906, 1924, and 1944 and less powerful eruptions in 1921 and 1933; Etna erupted in 1924, 1928, and 1935. Because of its history, Vesuvius, near Naples, is the best known volcano in the world. After a long period of quiescence, eruptions of Vesuvius in A.D. 79 destroyed the cities of Pompeii and Herculaneum. In Hawaii, important activity of Mauna Loa occurred in

1903, 1907, 1914, 1916, 1919, 1926, 1933, 1935, 1940, 1942, and 1949. Outside the 48 states of our country, there are three active volcanoes in Hawaii and scores of active volcanoes known in Alaska.

Volcanoes are common in the lesser islands of the West Indies, in equatorial East Africa, and in the Mediterranean, especially in Italy. Remote ocean islands like St. Helena and Mauritius are generally volcanic. There are even volcanoes in Iceland and Antarctica. There are said to be around 2,000 volcanic islands in the Pacific and many that have been reduced to shoals from wave erosion. The map (Fig. 154) shows that an active seismic and volcanic area nearly surrounds the Pacific in the shape of a large horseshoe. Another important area extends through the Mediterranean Sea to southern Asia.

Large areas of the earth's surface are covered with rocks of volcanic origin. Sometimes vast quantities of molten lava emerge from long fissures in the ground to cover old surface features with flows that cool one above another until the lava deposits have built large plateaus. The Columbia Basin, the Deccan in India, much of southeastern Brazil, and East Central Africa were formed in this manner. The Cascade Range is built mostly of volcanic material. The only volcano in the United States proper known to have been active since the middle of the nineteenth century is Lassen Peak in the Cascades of northern California; it erupted in 1914 and 1915. Indians reported eruptions of St. Helens and perhaps other peaks in the Cascades early in the last century, and within 1,000 years there have probably been eruptions in southern Idaho, central Oregon, and possibly in California.

Various materials come from volcanoes. Lava, gas, and various sizes of fragmental material varying from fine ash to huge boulders are blown out during eruptions (Fig. 156). Volcanoes that produce lava during eruption have rather gentle slopes, like Mauna Loa in Hawaii, but those that give off explosive debris form steep-sided cinder cones. The eruption of ash and cinders is most common toward the end of a period of vulcanism. Often a big volcano formed mainly of lava is surrounded by several satellite cinder cones resulting from the last volcanic activity in that region. Sometimes hot and poisonous gases are given off during eruptions, like that of Mount Pelée in the island of Martinique in 1902, which destroyed the city of St. Pierre, killing 28,000 people.

Volcanoes occasionally suffer tremendous explosions, probably as a result of the accumulation of superheated steam underground that literally blows away the upper part of the mountain (Fig. 157). Krakatoa, between Java and Sumatra, was blown to pieces in this manner in 1883. The Mount Katmai eruption in Alaska in 1911 and possibly in part the formation of Crater Lake in Oregon during prehistoric times represent other examples of this type of explosive eruption.

Volcanic eruptions often destroy human life, but where they are not too dangerous they may provide tourist attractions, as on Kilauea volcano in Hawaii, Lassen Peak, and Vesuvius. A more important effect on man comes from the relatively rapid decay of most volcanic rocks, producing very fertile soils in tropical regions. As a result, volcanic islands like Java can support large numbers of people by agriculture and have sufficient quantities of agricultural produce for export. The plantations of Hawaii, Fiji, and Mauritius also are favored by their volcanic soils.

Lava rock outside the tropics decays slowly, and areas of recent lava flow may be so rough, with very thin soil and little vegetation, that small use can be made of them by man. The Modoc Lava Beds in northern California and the Craters of the Moon in central Idaho are examples of recent lava flows. Very rough recent flows are sometimes called *malpais* (literally "bad country") by the Mexicans in the Southwest.

Intrusions of Igneous Rock. Various names are applied to the different forms of intrusive molten rock that has solidified underground. Fillings of cracks in the bedrock are called *dikes;* sheets of intrusive rock are *sills;* dome-shape intrusions with a flat base are *laccoliths,*

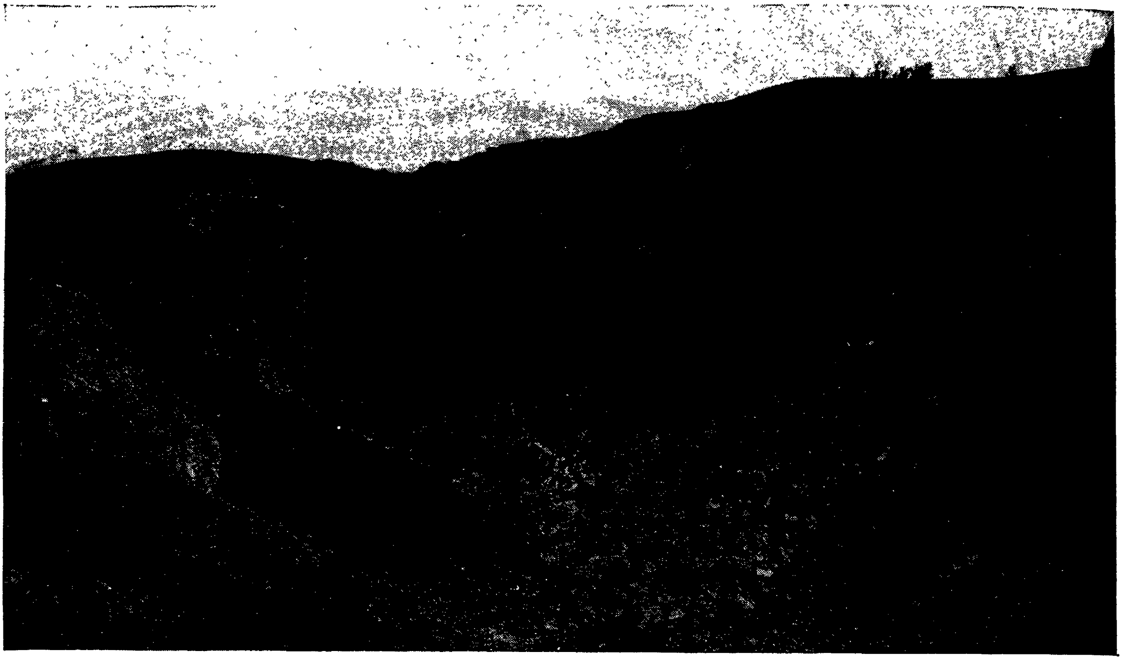

FIG. 156. A volcanic crater of recent geologic origin in Craters of the Moon National Monument, Idaho. Vegetation has not yet had time to become established on this loose rock material. (*Photograph used by permission of the National Park Service, Department of the Interior.*)

FIG. 157. An active volcano on Ile Ambrym, New Hebrides group, in the south Pacific Ocean. View toward the southeast. (*Air Force photograph.*)

some of which form several mountains in the western United States; and the very large intrusions forming the cores of some mountain ranges are called *batholiths*. Metals are commonly associated with intrusions of igneous rock deep underground. Many of the metal-mining districts of the world are located in ancient areas of vulcanism, exposed at the surface by erosion of former overlying rocks. The diamond deposits in South Africa were formed in intrusive "pipes" of lava. Much of the building stone of the world is of intrusive igneous origin like granite. Intrusive rocks are often harder than adjacent rocks of other character, and in these cases they may be left to form hard-rock ridges, flat-topped buttes and mesas, and other elevations after the softer rocks have been eroded.

Problems

1. How does the volume of flow of a stream affect its usefulness to man?
2. Why is the Missouri River called the "Big Muddy"?
3. Why does the Colorado River carry a heavy load of silt?
4. Why are valleys usually more fertile than adjacent hilly land?
5. Why are flood plains sometimes avoided as sites for farms and cities?
6. What are some of the economic uses of streams in your locality?
7. Give an example of a stream in your vicinity that is modifying the area through which it flows.
8. Why do roadways often follow river valleys?
9. What are land forms?
10. Why are land forms in arid climates usually more angular than those of humid climates?
11. What processes of weathering are important in your locality?
12. What are factors determining the depth to which wells are drilled in order to obtain a permanent flow of water?
13. On what side of a mountain peak in mid-latitudes would you expect the snow line to be lowest?
14. What are factors determining the size and length of a valley glacier?
15. If you live in a glaciated region or have visited such an area, describe the field evidence that proves glaciers once existed there.
16. Along a coast, what would you seek to indicate that the coast has (*a*) risen or (*b*) sunk?
17. What changes occur along a shore resulting from (*a*) erosion and (*b*) deposition?
18. In what stage or stages of the cycle of erosion is your home area?
19. Near what shore of Lake Michigan are dunes best developed? Why?
20. What methods have you seen in use to control erosion by (*a*) running water, (*b*) wind, or (*c*) waves.

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CHAPTER 13: *Plains and Plateaus*

Plains

Plains are the most important land form from the human point of view, for most of the world's inhabitants select lowland plains for their homes. Only in the tropics does man prefer plateaus or mountains to the lowlands because of better health conditions and attractive coolness. Plains vary widely in origin, size, altitude, climate, and natural vegetation. Most have a rolling surface, but the local relief should not exceed a few hundred feet difference in elevation if a region is to be called a plain. The truly level and nearly level plains are usually comparatively small in area. In altitude the Great Plains of North America are actually higher than the Appalachian plateaus; they even rise above most of the Appalachian mountain ridges and summits, yet we call the area a plain because the land surface rises gradually toward the Rockies, though its elevation may exceed 6,000 feet above sea level.

A classification of plains based on their origins includes interior, erosional, coastal, lake, fluvial (river), delta, alluvial, and glacial plains.

Advantages of Plains. Fertile well-watered plains have geographical conditions that obviously are favorable for agriculture and the support of large populations. Commonly the building of waterways, railways, and highways is cheap and easily done without the problem of opening routes of transportation into and across rugged mountains. Road building is so easy that in the interior United States the highways are nearly always located on section lines (Fig. 16), arbitrarily following meridians and parallels, instead of being forced to occupy the easiest natural routes, as in more rugged areas. Farming on a plain is favored by the fact that nearly all the land can be tilled, erosion is reduced to a minimum, machinery can be used to advantage, transportation is easy, and markets are near at hand. All these advantages lead to intense utilization of such favorably located areas. In Europe, the United States, and Canada nearly 90 per cent of the population live on lowlands. All the great commercial crops of the world like wheat, corn, and rice, are grown chiefly on plains.

Plains often contain minerals of value. Fuels, coal, petroleum, and natural gas are widely distributed on plains. This is of special benefit to man, since many of these occurrences are near centers of large population. Building stone and clay for brick, drain pipe, and other clay products; cement materials; and material needed for road building are also commonly found.

Advantages and Disadvantages of Plains under Primitive Conditions. A primitive society located on grass-covered steppes that lack natural barriers for defense is peculiarly subject to attack by its enemies. Warlike horsemen can quickly overrun even the most extensive of interior grasslands. Thus the Mongols under Genghis Khan and Kublai Khan conquered all the open country from China to Poland during the Middle Ages. The forested parts of Europe were little affected by the invaders, since horsemen are repelled and not attracted by forests. Civilization seems to have developed first in river plains like those of Egypt, Iraq, the Ganges, and the Wei Ho in China where there was protection by deserts or mountains against warlike invaders. Here the agriculturists found safety and time in which they could peacefully develop their arts. Great steppes like those of Russia were too open to attack by the nomad, and their development in an agricultural way was left for a much later time when the farm populations

had increased in numbers and in power of defense.

Development of Civilization on Plains. In ancient times rather small plains, well protected by natural barriers against invasion and yet open to receive ideas and commerce by water routes or defensible land routes, were the favored areas in which came most of the advancements in civilizations. Examples include Egypt, Iraq, the Syrian coast, and the plains, valleys, and islands of Greece. The open grasslands were too exposed to attack by fierce nomads to be suitable sites for peaceful farming people. Much of the lowland area of northwestern Europe was covered by forests, and its population lived in small clearings, so isolated that contacts with the outside world were few and advancement was slow. The cost of transportation of bulky products like wheat across extensive plains was too high in ancient times for export crops unless waterways were available. With modern machinery, great plains are easily cultivated, and railways can supplement water transport in bringing products of the farms to the export markets. Modern armaments enable the agricultural peoples of the plains to protect themselves from the less numerous nomads and also help to enable the strongest tribal or racial group to develop the idea of nationality and to expand until it dominates large plains like those of Russia and northern Germany. If part of such a plain is occupied by a weaker group of people, they may be subject to attack by stronger neighbors, and their history will be one of continuous warfare and boundary changes; it was under such circumstances that Poland disappeared for over a century from the map of Europe.

Ease of Political Expansion on Plains. A great open plain is an encouragement to expand territorially. The mountains and forests of the eastern United States required a century and a half to be crossed by the English colonists; but, once the prairies had been reached, expansion of the remaining distance to the Pacific—more than twice the distance from the Atlantic to the grasslands—took only a generation. Today large plains tend to be occupied by single political units. The size and richness of the plains area of a nation in a large measure determine that country's ultimate relative importance among the other nations of the world.

Population tends to be evenly distributed over tillable plains, while in the mountainous regions the people are crowded within the small areas available for cultivation, giving very uneven distribution of population. Since transportation and communication are easy on plains, the inhabitants tend to lead similar lives, that is, to have a general similarity in cultural conditions. Contacts with each other lead to increased knowledge and the best utilization of available resources. Schools, libraries, hospitals, and other civilizing influences also are readily available to most people who live there.

Erosion Plains and Peneplains. Agents of erosion, like running water and wind, if given time, will completely reduce rugged mountains and high plateaus to gently rolling surfaces called peneplains, as described in Chap. 12. True peneplains have few prominent relief features, and only a few rounded hills may break the monotonous flatness of their landscape; but such are rarely found, although most of western Australia and much of Canada west and south of Hudson Bay are probable examples. Many partial examples occur widely distributed throughout the United States and the world, where rivers have locally reduced a higher level to a lowland.

Erosion plains are located in regions in which uplands have been reduced by erosion to form a plain with a rolling surface or low hills whose difference in elevation does not exceed a few hundred feet. On most erosion plains, the bedrock is deeply weathered and is often covered with good soil. Where the land is climatically suitable, such erosional plains are favored places for occupance. When well watered, the deeply weathered soil of erosional plains is favorable for agriculture and will support a large population. Such

plains occupy much of western France and part of southern Germany. The Bluegrass region of Kentucky and the Nashville Basin in Tennessee are examples in the United States. Erosional plains are not always well populated. They may be of rough relief even if differences in elevation are small, or the soil may be thin or poor like the rim surrounding the Bluegrass region of Kentucky. They may be too dry for agriculture like western and central Australia or too cold like much of interior Alaska and northern Canada. To be well peopled, any plain, whether erosional or of other origin, must have suitable climate, soil, and relief before it can be utilized for agriculture to any considerable extent by man.

Coastal Plains. Coastal plains represent former sea floors that have been uplifted. The bedrock is often soft and loosely consolidated where the plains are of recent origin. The soil may be sandy and poor, but even on the poor lands agriculture is generally carried on because of the ease of cultivation and the accessibility to markets in seaport cities. Terraces are common features of coastal plains, each level representing a renewed uplift of the land. Low hills may break the surface of the coastal plain where somewhat harder bedrock appears. These outcrops result where the bedrock dips toward the sea somewhat more steeply than the slope of the land itself. The resulting land form presents a steep slope inland and a gentle slope seaward and has been named a cuesta. These cuestas, previously described, developed on sandstone strata and are common phenomena of the Atlantic coastal plain; they present an interesting contrast to the more fertile areas developed on weak rocks between the more resistant exposures.

Residents of coastal plains often face the problems of poor drainage, and swamps are usual features of the landscape near the shores of these plains. For this reason, malaria is often encountered in warm coastal plain areas.

Among the well-known coastal plains of the world are those facing the North Sea and south of the Baltic Sea in northern Europe; the Campania between Rome and the Tyrrhenian Sea; the narrow shelf along the Malabar and Coromandel coasts of India; the peninsula of Yucatán; and the coastal plain along the Atlantic Ocean and Gulf of Mexico in the United States.

The Atlantic and Gulf coastal plain of this country is rich agriculturally and important commercially. A large variety of crops, including vegetables, fruit, peanuts, tobacco, and cotton, are grown; forest resources are important; and the many seaports serve both the interior and the coastal plain itself.

The chief rivers of coastal plains are usually navigable, and seaports are often located near their mouths. Hundreds of such ports have been founded, including Savannah, Georgia; Danzig; Hamburg, Germany; and Le Havre and Bordeaux in France.

The Fall Line. Since the rocks of coastal plains are relatively soft, streams that rise in an interior upland of resistant rock usually have falls and rapids at the contact between the hard rocks of the upland and the softer rocks of the coastal plain.

Along the Atlantic coast the contact between the hard crystalline rock of the Piedmont Plateau and the Atlantic Coastal Plain, called the fall line, is a feature easily traceable from New Jersey to Georgia (Fig. 158). The fall line determines the head of navigation on many streams and furnishes water power for manufacturing; this in turn leads to the establishment of many towns and cities. Among the towns whose locations are in part determined by their position on the fall line are Newark, Trenton, Philadelphia, Wilmington, Baltimore, Washington, Richmond, Raleigh, Columbia, Augusta, and Macon.

A similar fall line traverses central Germany, marking the contact between the older harder rocks of south Germany and the young weak rocks of the coastal plain in the northern part of that country.

River Flood Plains or Fluvial Plains. The flood plains deposited by rivers are of particular importance to man, for in these locations

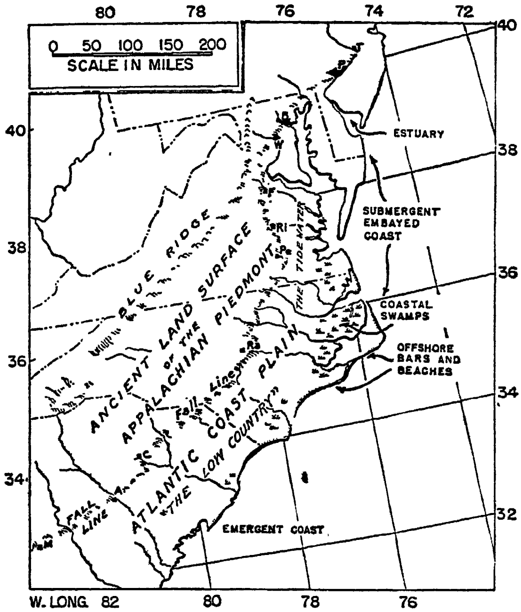

FIG. 158. The fall line and its cities: *T*, Trenton; *P*, Philadelphia; *B*, Baltimore; *W*, Washington; *F*, Fredericksburg; *Ri*, Richmond; *Pe*, Petersburg; *Ra*, Raleigh; *C*, Columbia; *A*, Augusta; *M*, Macon.

(Fig. 139) we find some of the world's most fertile soils, easy transportation, and prime sites for cities. Even small alluvial plains situated in favorable climates are very densely populated and support large cities as well as rural residents. Japan's river plains serve as excellent examples, because the majority of the inhabitants of that nation live on fertile fluvial and alluvial plains, many of which are small in extent. The Danube, Volga, Po, and Elbe rivers in Europe; the Ganges, Yangtze, and Yellow rivers in Asia; and the Mississippi, Sacramento, and San Joaquin rivers in the United States are some of the many streams of the world having flood plains that support large populations. This comes from the very great fertility of the soil in combination with favorable climatic conditions. Even the flood plains of those rivers which flow through deserts may, through the magic of irrigation, support dense populations of farming people and many large cities. The Nile Valley, the land of Iraq (Mesopotamia) between the Tigris and Euphrates rivers, and, most populous of all, the plains irrigated from the Indus River, are noteworthy developments in deserts.

Even when rivers flow through highlands and have cut deep canyons, some local flood plains usually exist, and such occupance as is possible centers at these little strips and parcels of level land. The Columbia and Colorado rivers have these characteristics, as well as the Brahmaputra River in Asia. The mountain sections of many rivers like the Yangtze and the Rhine also enjoy small arable stretches of alluvial ground though the lower courses of the rivers have formed famous alluvial plains.

River flood plains are formed when running water deposits part of the load of sediment it may be carrying when the slope (gradient) of the stream decreases and the current is retarded. In times of flood, rivers overflow their banks on either side of their channels and may cover most of the valley flats alongside the stream, where deposits of silt, gravel, mud, sand, and other material are laid down. The floodwaters themselves are disadvantageous to human residence on flood plains, but the replenishment of the soils of the plains more than compensates for damage by floodwaters.

Deposition of material occurs first immediately along the banks of most large streams; in this location the river forms low banks called natural levees which rise above the general level of the lower land away from the river. In themselves, the natural levees are inconspicuous features; but when they are surmounted by strong banks of artificial levees (Fig. 159) built for the specific purpose of confining the worst of the floods within the natural river channel, they provide considerable protection against flood damage. Natural and artificial levees are usually paralleled by low swamps known as the "back swamp line"; these poorly drained areas receive river water seepage through the levees and may also receive the waters of tributaries of the main stream that are unable to take their natural course because of interference by the levees.

FIG. 159. Flood conditions at Leland, Mississippi, during the great flood of 1927. Livestock and people have taken refuge from flood waters on the highest ground along the line of the rail embankment; this has been reinforced as a levee by dumping large amounts of soil in foreground. (*Photograph used by permission of the U.S. Weather Bureau.*)

The back swamps are usually serious problems for the people who farm the flood plains, for they provide breeding places for insects and may become a serious menace to the health of the residents.

A typical example of the condition described above may be found along the boundary of the states of Mississippi and Louisiana, where the Yazoo River, flowing into the Mississippi River from the east, is forced to flow parallel to the main stream for a number of miles before it finally joins the Mississippi below the city of Vicksburg (Fig. 160). The low ground between the Mississippi levees and the Yazoo is marked by numerous swamps and lakes; where drainage is possible, this land is very fertile and produces excellent cotton and much fruit. The swamps and lakes often are semicircular in form and represent the abandoned stream channels of the Yazoo River. Lakes of this type are known as oxbow lakes, and they are characteristic features of many river flood plains.

It is apparent that a low, level river plain will offer slight resistance to any changes that may occur in the channel of the river, for natural and even artificial levees often fail to keep the river within bounds in flood time. When the gradient of the stream is slight, the channel may undergo numerous changes within the course of a single year. One of the conspicuous results of changes in the channels is the presence of wide-swinging river bends known as meanders. They are relatively unstable features of the landscape and may be almost entirely eliminated in a single season if the river channel cuts across the neck of these meanders and leaves them as oxbow lakes in its plain. Meandering streams are something of a hindrance to navigation, for they are many miles longer than streams whose channels are straight. Furthermore meandering streams are often shallow and must be dredged to maintain adequate depths for shipping. The side-to-side swing of the river meanders tends to erode the river valley and widen it; such valleys often are marked by

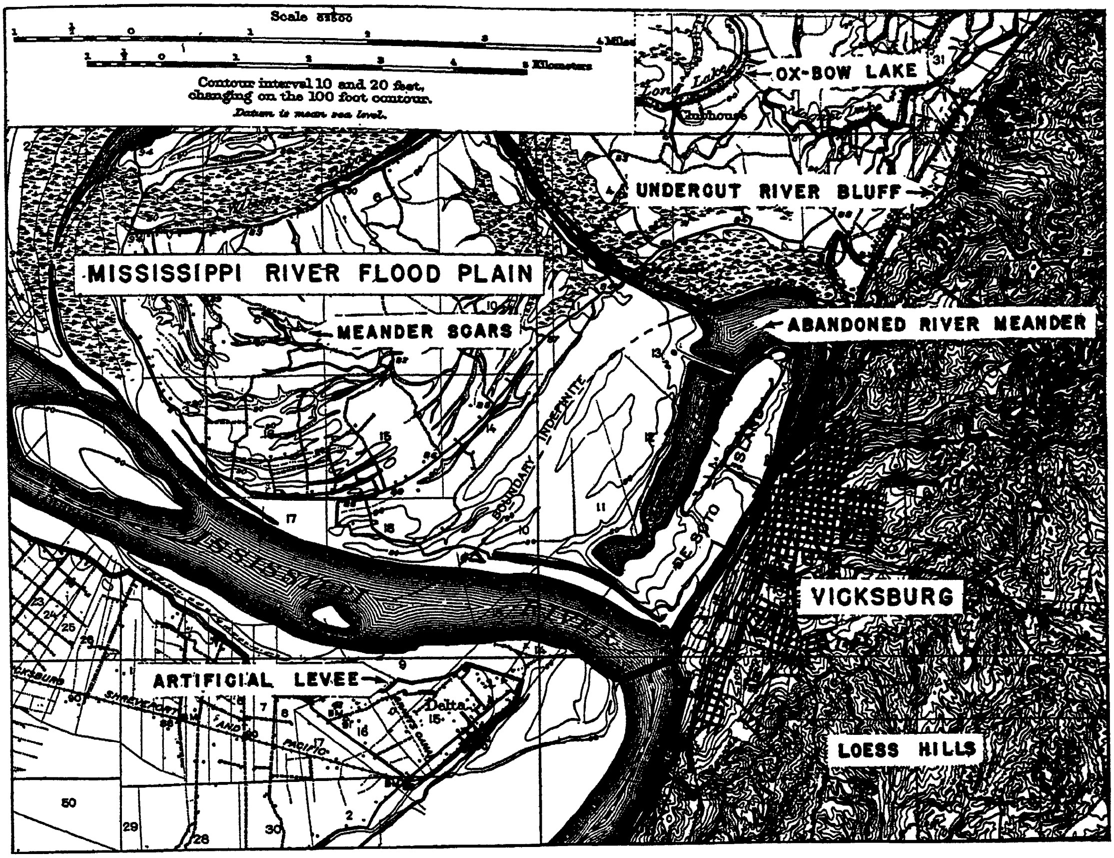

FIG. 160. Part of the Vicksburg, Mississippi, contour map published by the U.S. Geological Survey. Note the relationship of the city to the nearby flood plain and the commanding location overlooking the river bend.

high bluffs on either side of the river, but at some distance from it. Conditions along the Mississippi River flood plain follow this pattern.

There are many river flood plains in different parts of the world, but not all are suited to intensive use by man. Unless their climatic conditions are favorable for agriculture or other activities, they can contribute little to human welfare. The river plain of the Mackenzie in northern Canada, for example, is situated so far north that it is extremely unattractive for farming; it is occupied by very few people in relation to its vast extent. Other flood plains that are too cold for the support of many human beings are found along the northward-flowing streams of the northern part of Siberia, the Lena, Ob, and Yenesei.

Delta Plains. Deltas form at the mouths of muddy rivers flowing into quiet bodies of water, at the seaward extremities of river flood plains. They are often triangular in shape—a fact that served to name them. Delta lands consist of the richest soil washed from the lands farther upstream; and often this forms productive and populous farming regions, especially on some deltas that are located in the tropics and the Orient. Familiar examples of deltas include those of the Rhine (Fig. 161), Mississippi, Nile, Ganges, Tigris, Rhone, Volga, Mekong, and Hwang Ho. Deltas under a desert climate, like those of the Nile and the Colorado, may become very productive when they are irrigated by water taken from the nearby rivers. Deltas are low in relief and therefore are subject to flooding; dikes are

FIG. 161. Dutch windmill used for drainage of polder lands near Domburg, Zeeland. Neat hedges separate the fields and paths in this orderly rural landscape. (*Photograph courtesy of the American Museum of Natural History, New York.*)

needed to protect farms and cities from inundation. Like coastal plains and river flood plains, they are often swampy and subject to poor drainage (Fig. 162), in which case they are nearly unpopulated, like the delta of the Orinoco. The delta lands of the Mississippi and the Rhone are difficult to reclaim and are less used than higher land for farming.

Because they are productive of agricultural wealth and are situated at the entrances to great river plains, delta communities frequently emerge as cities of some size and importance. Cities whose locations are related to delta plains include Cairo, New Orleans, Barranquilla and Cartagena, Venice, Marseille, Amsterdam, Astrakhan, Calcutta, Rangoon, Basra, Karachi, Shanghai, and Canton.

Delta cities sometimes have special problems, and the conditions that prevail at New Orleans are typical of many. Originally, with its drainage basin largely forested, the Mississippi sent down annual floods of normal volume that were not unduly destructive. Of late years, however, with much of the former forest cleared and swamps drained, the river has become increasingly difficult to control and has threatened the safety of residents of New Orleans many times. The city was barely saved from destruction in the great flood of 1927. It has been completely ringed by levees and equipped with pumping plants to lift excess rain water out of the center of the saucer in which it is located, and it has been forced to relocate the shifting channel by which it has maintained its position as a seaport. The residents of New Orleans had trouble in finding adequate material for building roads; they had to construct an expensive plant for purification of water supply for the city; and they had to fight a number of threats of epidemic diseases when the drainage problem around the city became serious. In this delta city they have even had trouble finding a solid foundation for the business structures and the approaches to their river bridge. Few other major American cities have had to face geographical problems like those imposed upon New Orleans because of her delta position.

Lake Plains. When lakes are filled with sediment and peat or disappear through evaporation, drainage, or other causes, they leave in their old beds a plain of silt and plant remains that may afford very fertile farm land. If the plain is too swampy for cultivation, the farmer may build drainage ditches to reclaim the land for agriculture. The Red River Valley in Minnesota and the eastern Dakotas is a good example of the value of lacustrine (lake-bed) farm lands, since a large deep lake that once extended into Manitoba occupied this region during the last glacial period. This former lake, called Lake Agassiz, once overflowed southeastward through the Minnesota River to the Mississippi. Other former lake beds occupy lands south of Lake Erie

FIG. 162. A tropical delta: the mouth of the Pogo, or Waponngaa, River as it enters Geelvink Bay, New Guinea. Note the dense rain-forest-vegetation cover merging with the coastal swamps. The larger stream is heavily burdened with silt that is carried some distance into the bay; the smaller stream remains relatively clear. (*Air Force photograph.*)

and Lake Ontario, areas around Great Salt Lake, Death Valley, and the Takla-makan in central Asia. Former glaciated regions contain thousands of little plains that are the sites of former ponds or lakes now filled or drained. These constitute some of the best farm land in these parts of Europe and America (Fig. 149). The limits of these former lakes are determined by the presence of abandoned beaches, sand dunes, wave-cut cliffs, terraces, exposed deltas, and sand bars.

Alluvial Piedmont Plains. Running water flowing from higher lands may deposit material in the form of alluvial fans and cones at the mouths of valleys or canyons where the gradient of the stream bed changes abruptly. These alluvial deposits may coalesce until they combine to form wide alluvial slopes or compound alluvial fans extending far out from a mountain range (Fig. 144). When these plains occur at the bases of mountains, they are known as alluvial piedmont plains, as described in an earlier chapter. Typical alluvial piedmont plains are found on the eastern side of the Great Valley of California; the northern side of the Po River plain; the eastern slope of the plains of Iraq; the northern side of the Indus and Ganges river plains, and the western slope of the Wasatch Range in Utah. These alluvial plains merge by insensible degrees with fluvial deposits like those along the Sacramento and San Joaquin rivers in California. Alluvial plains are generally fertile and when well watered, by either natural rainfall or irrigation, may support great numbers of people, as in India. As a rule, alluvial plains of this type are limited to arid or semiarid climates, with the notable exception of the great piedmont at the southern base of the Himalayas, which has been formed in a humid monsoon region.

Interior Plains. Some of the most extensive plains on the face of the earth occupy the interior of continents. Examples are the Great Plains of America; the great European plain extending from the North Sea across to Rus-

sia, and the plain of west Argentina, which extends north into eastern Bolivia, Paraguay, and interior Brazil. The great European plain and that part of the central United States which receives adequate rainfall include great areas of fertile land, support many large cities with their associated industries, and constitute some of the most important economic regions on earth. In contrast, some other interior plains, like the llanos of southern Colombia and central Venezuela, the Sudan region of Africa, southwestern Siberia, and other parts of inland Asia, are seas of grass, devoted to grazing of wild game and domestic cattle. They are peopled with scant numbers of hunters and herdsmen. These plains are difficult to reach from the sea, and because of their isolation the inhabitants tend to be self-sufficient rather than maintain numerous cultural and economic contacts with the rest of the world.

In general, interior plains are characterized by low relief and have relatively few obstacles to the development of modern methods of transportation. Those plains which have soil and climate favorable to settlement and economic development are generally well served with railroads and highways. Interior plains, located in middle and high latitudes toward the centers of continental land masses, usually experience very severe climatic conditions of continental character, for the influence of the sea air seldom reaches great distances into the hearts of continents. The severity of the climate prevents some crops from being grown and is a handicap to the inhabitants. The lack of pronounced relief features on interior plains was an advantage to the United States and Canadian governments when they divided large tracts of land according to a survey system based on geographical coordinates; and most of the interior parts of both nations have been allotted to settlers on the basis of these rectangular surveys. The cultural landscape evolving on lands divided by such surveys is quite different in appearance from that of the Polish or German countryside, where other schemes for land division have been established.

Plains are readily invaded by modern mechanized armies; this occurred in Poland in 1940 and has happened repeatedly throughout the course of history, but the vast extent of the plains of a country like the Soviet Union lends itself readily to military defense, for it is possible for armies to retreat to the interior without suffering disastrous defeat. This plan was followed by the Russians during the Napoleonic wars and more recently in their retreat to Stalingrad; when the communications of the invading armies were greatly extended, the Russians successfully counterattacked.

Glacial Plains. Ages ago, gigantic ice sheets accumulated in North America, northern Europe, and other parts of the earth which were then experiencing very low temperatures. In North America, these continental glaciers extended southward as far as New Jersey, Pennsylvania, central Ohio, Iowa, and Kansas (Fig. 139). The moving ice sheets materially modified the natural landscape of these regions. Valleys were sometimes filled with debris, thereby reducing an original steep relief to a less rugged condition. In other places, lobes of the ice sheet gouged out vast quantities of material from ancient river valleys and dumped it in elongated heaps around the excavated basin. When the ice melted, some of these depressions were occupied by lakes, the greatest example marked by the Great Lakes of North America. Some of the material deposited at the end of a melting glacier formed long irregular-shaped hilly ridges called terminal moraines. Parts of the glacial deposits may be very stony, thereby interfering with agriculture, but on the whole the effect of the glaciers was to reduce the topography, leaving it smoother than it was originally.

As the ice melted, quantities of sand, silt, and gravel were deposited to form gently sloping outwash plains. Everywhere as the ice melted away, boulders, clay, and every sort of material contained in the ice were

dumped at random, forming the so-called *glacial till* which covers the whole country in the northeastern United States. This debris oftentimes filled old valleys and compelled complete readjustments of drainage lines. Tens of thousands of lakes that date from the glacial period are scattered over parts of the glaciated plains. Some of these have become filled with silt or vegetation, and when drained they form some of the finest available farm land in the area. A small part of southwestern Wisconsin and adjacent corners of southeastern Minnesota and northeastern Iowa were never covered by any ice sheet and are known as the *driftless area;* in these places there is a rugged relief and much less good farm land than in adjoining glaciated regions. Similar hilly lands of inferior value for farming are found in southern parts of Ohio, Indiana, and Illinois beyond the limits reached by glaciers. Parts of Canada and many New England hills were damaged when they lost much of their soil by glacial erosion. Parts of northwestern Europe also suffered from severe glacial erosion. Scandinavia, Finland, and Scotland have had much of their best soil removed by this process.

In general, glaciated parts of the continents form plains of less relief than before glaciation, though they display much irregularity of surface in a minor way. As far as the United States as a whole is concerned, the continental glaciers benefited man by reducing the relief, improving the fertility of the soil, creating lakes of value for transportation and other purposes, causing many waterfalls and other power sites, and depositing sand, gravel, and clay of value for construction materials.

Forested Plains. Plains have few barriers to impede the movement of people across them except when they are covered with forests. The great rivers draining the plains are far more important arteries of travel than barriers to human movement, but a forested plain may present greater difficulties to travel than a high mountain range. Explorers long ago penetrated essentially all parts of the Andes, but large forested areas of interior Brazil are still virtually unknown except along the rivers.

Originally plains with suitable climate supported dense forests (Fig. 55). In the east-central United States and in western Europe the lowlands were covered with hardwood trees growing in excellent soils. In these regions the forests have been largely cleared away and the land has been brought under cultivation, enabling a larger population to be supported on the land. In colder parts of northern Europe, Asia, and America, the forests are of coniferous trees, the climate is harsh, and the soils are inferior. These areas naturally are less useful for crops and support only sparse populations. The tropical forested plains likewise have more repressive effects than favorable influence upon man and support fewer people than might at first be expected. Tropical hardwoods are difficult to clear and the climate is unfavorable for human exertion, facts that are among the handicaps slowing up the settlement and utilization of plains covered with tropical rain forests.

The Steppes or Grassy Plains. Plains in the interiors of continents in middle and high latitudes have extremes of climate, with very cold winters and hot summers, since they may lack barriers such as east-west trending mountains to help keep out both cold and warm air masses. On the Great Plains, July average temperatures in Dakota and Montana are only 10 to 15° below those in Texas or New Mexico, while January average temperatures may be 50° colder in the northern than in the southern Great Plains. Of course the cool nights in summer in Montana and New Mexico are quite different from summer nights in the coastal plain of Texas.

Great interior plains remote from the oceanic sources of rainfall have semiarid and even desert conditions (Fig. 104). Trees grow only in strips along the few waterways, with grass forming the main vegetation cover under semiarid conditions. These grasslands, previously described as steppe lands, support vast herds of big-game animals. In America the

bison (buffalo) was the main support of many thousands of roving Indians. In Asia animals of a docile temperament were domesticated, and the natives there advanced beyond the hunting stage of civilization attained by the American Indians and became stock raisers.

Changes in Man's Utilization of Plains. Man's use of grasslands varies with his stage of economic development. As hunters, residents of the steppes live entirely on the animals that can be captured and the few roots and berries that are available by gathering. The Indians on the Great Plains cooperated in hunting the buffalo and other game, just as do the natives of South Africa or the Sudan, and as the Indians of Patagonia once hunted the guanaco—by driving the game into traps or over cliffs and using other mass methods of killing. Large numbers might be secured in this fashion at one time, and the meat when dried could be kept from a time of abundant food supply and then used in time of scarcity when the wild game had migrated to other pastures. This cooperation and planning, with provision for future supplies of food, result in the development of stronger and more warlike tribes than those living in small or isolated environments.

The introduction of domestic animals changed man's occupations on the Great Plains in North America. The buffalo were exterminated, the Indians were restricted to reservations, and the "sea of grass" was utilized by vast herds of half-wild cattle. These were tough animals capable of surviving droughts of summer and the freezing cold of winter, having long legs and sharp horns that enabled them to travel long distances and to defend themselves against wolves and mountain lions. At first the grass belonged to anyone. Later it was monopolized by those who secured control of sources of water, and finally the open range passed into private ownership and came under cultivation. The better grazing land was fenced, and that suitable for tillage was devoted to grain. Hay was provided for the animals, and improved breeds of livestock were introduced. This change from Indian country to the open range for cattle, and then to a combination of grain farming and livestock production took place in less than a generation on our grass plains. Similar changes in land use may be noted in Argentina and in other parts of the world.

Nomadism on Plains. In central Asia, whole tribes of Mongols, Kirghiz, and others are wholly supported by the products of their flocks and herds. They have no permanent home but occupy a general region over which they roam as necessities of grass and water for the livestock require shifting camp frequently. Their yurts, described in Chap. 8, are similar in arrangement to an Indian tepee (Fig. 121). Among the Asiatic nomadic herdsmen, as among the American Indians of the Great Plains, the erection of the hut is part of the woman's work. When camp is moved, the men carry weapons for hunting and to defend the tribe. They drive and guard the animals and cannot be bothered with tent building. In the summer the members of the tribes—men, women, and children with all their belongings—accompany the beasts into the mountain pastures. In the winter lowlands or other areas most free of snow and most sheltered are utilized. The people are horsemen, and it is almost literally true that a child learns to ride before it can walk.

The lives of these nomads are not easy. Their land has short hot summers and long cold winters. They must guard their herds against the attacks of wild animals. They must care for the creatures in the midst of severe snowstorms and cold. They must sometimes fight their human enemies to secure the needed grass and water or to protect against thieves. At times the work is extremely hard, exhausting, and dangerous. Only courageous men of great fortitude can survive the hard conditions. Weaklings perish or leave the tribe to find an easier life by cultivating the soil or living in the cities. At other times there is little to do, and then the men may rest for days and even weeks recuperating from the severe life they lead.

All the furniture and belongings of these

people are carried with them everywhere. Their tents and beds must be easily portable. The Kirghiz keep warm in winter with heavily padded clothing similar to that shown in Fig. 85. They sleep warmly under home-woven rugs and blankets and the skins of animals dressed with the hair left on. The cooking utensils are reduced to a minimum and are of metal or wood that will not break like pottery. Instead of wood for fuel the Asiatics use the dry dung of domestic animals, just as the American Indians burned "buffalo chips." The family eats from a common dish. Most of what they have, both food and clothing, comes from their herds. The chief animals in central Asia are horses, cattle, sheep, and goats. In the deserts the heavy-coated Bactrian camel with two humps is kept, and in the highlands of Tibet the chief domesticated beast is the yak.

Lack of sufficient numbers of animals to allow them to live exclusively on a meat diet causes many of the nomads for weeks at a time to consume mostly milk from their animals. Often this is used in the form of kumiss, a weak alcoholic fermented drink manufactured by placing the milk in skin sacks containing nodules or berries of bacteria that cause a type of fermentation. Milk sours anyway in the hot summer; and, since the natives lack means of refrigeration, they secure a food product that they prefer by controlling the type of fermentation. Wool, hides, and animals may be traded to neighboring farming peoples in return for a limited amount of barley and other grains which supplement their milk and meat diet. Their clothing is mostly made from the skins, wool, and hair of their animals.

The Kirghiz and similar nomads lead a hard life according to American standards, and their country is unattractive to highly developed civilized peoples, but they have many desirable characteristics. They are brave, hardy, healthy, and hospitable. They possess great endurance and when necessary can work for days on end in fierce blizzards or severe cold to protect their herds. Then for days and weeks they may have little to do. Such great exertion and spending of physical energy followed by long periods of rest characterize the life of most nomads. They are not lazy; they merely do not have to work steadily. In towns their habit of working a little and then resting much is unsatisfactory, and they are likely to degenerate into sickly, dirty, and despised individuals, far removed from their appearance while living their former free existence on the open steppes.

The Oriental Rug. The so-called Oriental or Persian rug originally was a good example of the relation of steppe peoples to their environment. The nomads had a surplus of wool beyond their needs for their own clothing and tents. They also had plenty of leisure for other occupations, since most of the time the herds could be watched and tended by only a few members of the tribe. With experience, these primitive herders learned to weave rugs and other articles and attained great skill in their manufacture. They desired a permanent and portable covering used in their tents. Their sheep furnished the required raw material, and the wool was dyed from native plant sources that furnished colors of great beauty, lasting better than the artificial dyes of today. The beauty of design and construction of the woven articles made by the nomads have rarely been equaled. Many of their rugs are genuine works of art rather than floor coverings and were used for interior decoration. Outsiders who admired the rugs gladly traded products needed by the nomads for them. Rugs were also valuable enough to afford the slow expensive caravan transportation to market, and thus the rugs originally made by nomads to supply their local needs for portable floor coverings in a cold windy winter climate later became a valued article of commerce. Today many of the rugs are made in the cities of the Orient, and the dyes are generally the cheaper imported aniline dyes instead of the lasting native article, but some of the finest rugs still come from the deserts and steppes of central Asia (Fig. 163).

FIG. 163. Some of the important centers of rug manufacture and markets in southwestern Asia.

Plateaus

Plateaus resemble mountains in their elevation but plains in their comparative levelness. Technically a plateau is an extensive flattish area that has been uplifted without essential deformation. Plateaus are somewhat more difficult of access than plains because they often are reached by an abrupt ascent. The resulting isolation may lead to greater conservatism among their inhabitants. Thus the plateau of Judea retained the Hebrew religion in its most pure form while the more fertile lowlands broke away from strict religious observances as a result of more contacts with foreigners. In middle latitudes high plateaus may have harsh near-polar climates, as in Tibet (Fig. 164). Here man struggles against the severities of a climate and ekes out a scanty existence by stock raising and a little agriculture carried on in the more protected places. In an equal area in the same latitudes in China proper, nearly half a billion people live. In the southwestern United States, the high Colorado plateaus have more rain and support forests and lush meadows, while the lower altitudes around them are desert-like in character. Here altitude is an advantage for the lumberman, stockman, and dairy farmer. The Colorado Plateau also supplies much of the water for irrigation by which numbers of people have conquered part of the nearby desert.

In the tropics, plateaus are generally preferred to lowlands for human activity, since the climate is less enervating and healthier. Thus the plateaus of southeastern Brazil, the Deccan in India, and the high plateaus of

FIG. 164. Tibetan priests (lamas), engaged in painting sacred pictures. People on this high plateau at altitudes greater than 10,000 feet must dress in woolen garments to protect themselves against temperatures that are seldom very warm even in full sunlight. (*Photograph used by permission of the U.S. National Museum.*)

tropical and central America and northwestern South America in Peru, Colombia, and Ecuador are favored parts of those countries. Generally plateaus are less desirable for human use than plains. Canyons often isolate the level land, making it difficult to transport produce to market and causing the same backwardness among the inhabitants that is so characteristic of the people in isolated mountain regions. The highly dissected Ozark Plateau and the Appalachian Plateau in West Virginia, eastern Kentucky, and adjacent areas form good examples. The great canyons that cross the Colorado Plateau are almost impassable barriers to travel, though communication is easy on the broad tablelands between the canyons.

Except in the tropics, plateaus are generally less favorable for occupance by man than lowlands, and they usually support fewer inhabitants than the plains if the latter are humid and not mere desert. The principal human occupations on the plateaus of the world are grazing and forestry. They are unfavorable for farming except in the tropics, and they seldom support large cities. Some like the Appalachian Plateau contribute important quantities of coal, oil, natural gas, and building materials for man's use, but others like the Colorado Plateau are essentially barren of minerals.

PROBLEMS

1. How may a plain become more rugged?
2. How can rugged land become more level?
3. Why do some lake plains require drainage before they can be farmed?
4. Why does the type of vegetation on plains often vary widely?
5. Why are not all plains densely populated?
6. How can man increase the natural productivity of land on plains?
7. Why are plains in mid-latitudes more generally useful than those of low and high latitudes?
8. What are some possibilities for recreational activities on plains?
9. Why is travel difficult across most high plateaus?
10. Outline the handicaps that face river transportation on the Hwang Ho, the Indus, the Lena, the Volga, the Missouri, the Columbia, and the Mississippi.
11. The Mississippi and the Mackenzie are large rivers; they are nearly the same length; they flow through wide lowlands; they have well-

developed deltas. Account for the difference in human population within their valleys.
12. In a dry country, what advantages has an alluvial plain for irrigation?
13. In mid-latitudes, why do many deltas support large populations?
14. What advantages has a city located on a large fertile plain with regard to commerce and manufacturing?
15. How does the location of mountains affect human occupance and industries on plains?
16. Compile a list of large cities whose sites are related to (*a*) deltas, (*b*) flood plains, (*c*) coastal plains.

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CHAPTER 14: *Mountains and Hills and Their Human Relationships*

Mountains are earth features of greater degrees of relief than hills; their surfaces normally have less level land than plateaus or plains. Whether a particular area will be called hilly or mountainous is determined both by the actual elevation and by comparison with the height and steepness of neighboring land features. Mountains and hills affect men in numerous ways of interest to the geographer. Their beauty, industries, use for recreation and health, and influence on routes of trade or travel, as well as the irregular distribution of their population, make a study of mountains geographically important.

Mountains

Origin of Mountains. Details of the origin of particular mountains form part of the study of geology, but the matter becomes of geographical importance if mountains originating from different sources have diverse effects upon human affairs. Among the types of mountains are those formed by folding, faulting, intrusion of igneous rock, volcanic activity, and intense erosion of high plateaus. As mentioned in a preceding chapter, a cordillera is the whole system of mountain ranges, groups, ridges, and peaks (the Rocky Mountains, Andes, and Himalayas are excellent examples of extensive cordilleras). Mountain chains and ranges may rise separately from others, but often the boundary that divides them is only a valley or even a somewhat arbitrary line, as among the so-called "mountain ranges" of northern Idaho. The highest summits are generally given individual names like Pikes Peak or Mount Shasta. Even the term "hills" is sometimes applied to a mountain group like the Black Hills in South Dakota, which are really mountains.

Folded mountains usually consist of long parallel ranges or ridges. Valleys in youthful folded mountains occupy the downfolds, as in the Jura Mountains west of the Alps. Sometimes prolonged erosion of folded mountains modifies the location of the ridges in that the upfolded rocks and weaker strata may be removed faster than other bedrock, until finally the valleys come to occupy the outcrops of the weaker rocks, with the more resistant beds left to form the mountain ridges (Fig. 165); these conditions prevail in the Appalachian Mountains. In folded mountains where the trend of the folds is parallel, men can follow the elongated valleys between the ridges rather easily, but human travel crosswise over such mountains is very difficult because of the many ridges and rivers that are encountered.

Faults (breaks in the earth's crust) are common causes of mountain uplift. Where the faulting has occurred recently, geologically speaking, the face of the upraised mountain block rises abruptly from the plains at its base without the intermediate foothills that usually form a transition from mountains to plains. The Front Range of the Rockies in Glacier Park, the east front of the Sierra Nevada (Fig. 166), and the western face of the Wasatch Range in Utah have resulted from faulting. These mountain escarpments are difficult to cross and form important barriers to transportation. The main routes of travel generally follow deeply eroded canyons that cut across the high faulted mountains, thus avoiding the steep fault slopes

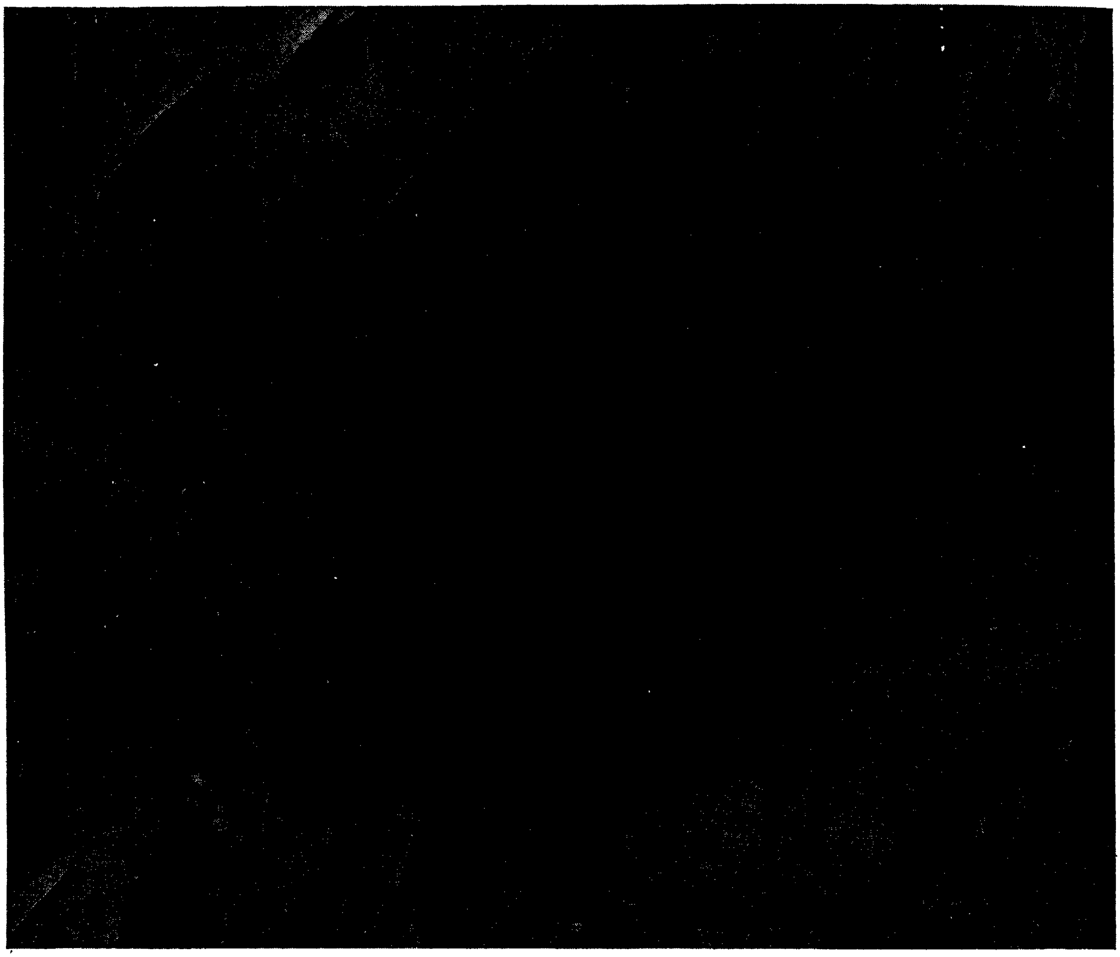

FIG. 165. Hogback ridges south of the Atlas Mountains in Morocco. Note the desert character of the landscape and the evidences of erosion even in this dry climate. (*Air Force photograph.*)

wherever possible. Isolated fault blocks sometimes have been uplifted to form island-like mountain masses rising above surrounding valleys and plains, like the "basin ranges" of Nevada.

Igneous Intrusions. Sometimes gigantic masses of molten rock have intruded other rock materials and produced vast upheavals on the earth's surface. The heart of many mountain ranges like the Sierra Nevada, the Rockies of central Idaho, and the Pacific Coast Range of Canada consists of great intrusions of masses of granite called batholiths. The intrusive rock is usually hard and resistant to erosion and often forms the mountain summits after the more easily eroded rocks that once covered and surrounded the intrusions have been removed by erosion. The dome intrusions with a flat base called laccoliths are also the cause of some mountains like the Judith Mountains of central Montana and the Henry Mountains of Utah, which occur as isolated groups.

Volcanoes have helped form many mountains. Sometimes the resulting lava flows may build up a rather broad plateau-like mountain range like the southern Cascades in Oregon, or a broad dome like Mauna Kea and Mauna Loa in Hawaii. More frequently volcanoes form individual piles or cones of lava and

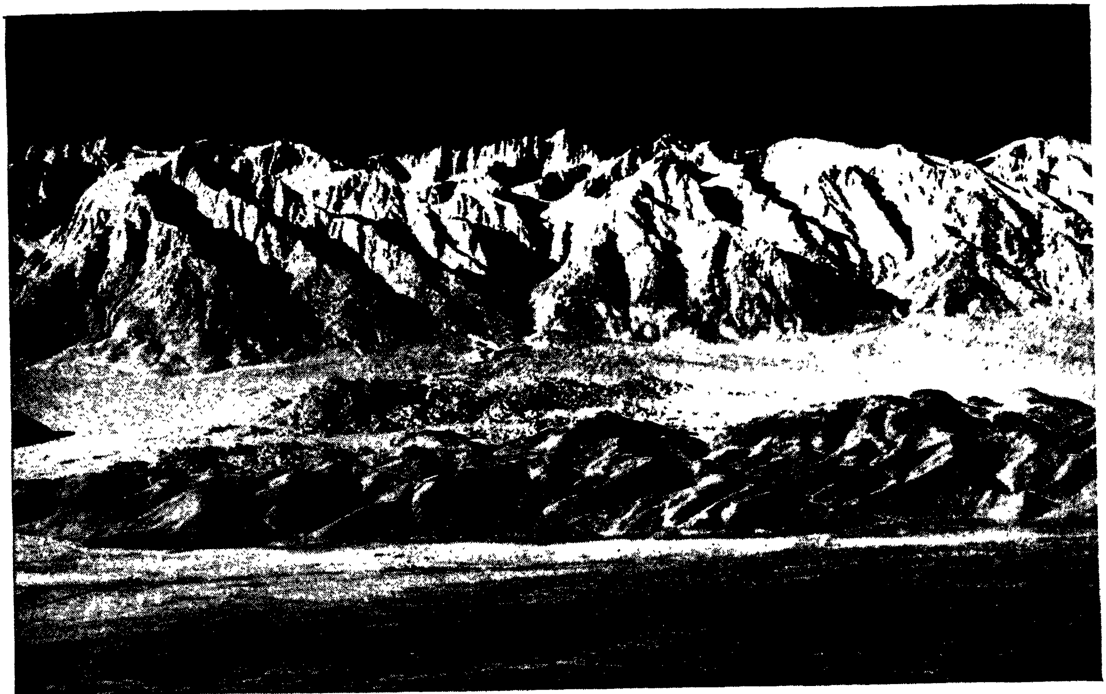

FIG. 166. Eastward face of the Sierra Nevada with the Alabama Hills in the middle distance. The highest point on the sky line in the center of the picture is Mount Whitney. Note the deep dissection of the face of the escarpment and the extensive development of alluvial fans and cones at the base of the escarpment. The floor of Owens Valley appears in the foreground.

explosive volcanic debris. Volcanoes may occur as isolated peaks, but they are arranged more frequently in rows that have been built up along some line of weakness in the earth's crust. Frequently smaller parasitic cones surround a major volcano. The lava domes have comparatively gentle slopes. In contrast the volcanoes formed of cinders or a mixture of lava and cinders are generally steep-sided cones like Fuji in Japan, Mt. Vesuvius near Naples, or Lassen Peak in northern California.

Plateau Erosion. When a high plateau has been deeply trenched by valleys until little of the original level summit surface remains, the region resembles a mountain area in its effects on travel and occupance. Such a dissected high plateau region occurs in northern Idaho and adjacent parts of Montana and Washington. When these eroded plateaus have been reduced to conditions of slope in which only remnants of the original level surface remain perched on the ridge summits, the relief may be sufficiently rugged so that they are regarded as hill lands rather than as plateaus. This has occurred in the case of the so-called Allegheny and Cumberland plateaus in the United States and in some other hill regions. Usually the dissection of the level plateau requires a long time, and such a region is said to have reached a condition of maturity in its relief. The Appalachian Plateau is an excellent example of a mature region. As more time elapses, the divides between its rivers are lowered by erosion, the valleys become very broad, and finally what was once a high level plateau may be reduced to a gently rolling plain or peneplain.

The way in which rivers develop water gaps through ridges was mentioned in the discussions on erosion in Chap. 12. In a maturely dissected plateau or in mountain systems composed predominantly of elongated ridges, lines of travel follow the rivers, and the location of the water gaps is a dominant control over

routes of trade. In the Appalachian region, the Indians discovered the trail, which was perhaps first made by buffalo and deer; then it was blazed by the fur trader and frontiersman; next it was widened for use by the Conestoga wagon of the emigrant; and finally it was followed by the railroads and paved highways of the present. The valleys, water gaps, and other passes in the maturely eroded mountains of southern and southwestern Germany have controlled in a similar way the settlement and routes of commerce in that area.

Man and the Cycle of Erosion in Mountains. No sooner has a mountain begun to be elevated above its surroundings than it is attacked by forces of erosion that tend to destroy it. In the resulting series of changes, or cycle of erosion, the different characteristics for the stages of youth, maturity, and old age grade into each other by insensible degrees.

In youth, mountain streams have carved narrow deep gorges, and there is very little level land on which man can live. The streams are too swift and broken by falls and rapids to use for navigation. Youthful streams may be developed for power, but there is little use for the energy because of the small population in mountains. Man avoids the gloomy chasms and makes his home on the more level divides between rivers. These are apt to be narrow with little level land for farming, and indeed they may reach such high elevations as to be climatically unsuited for agriculture. On the steep slopes soil is thin and poor chiefly because of the rapidity with which erosion may remove the finer particles. Usually few people live in young mountains because they are not attracted by the narrow valleys with only small areas of level or gently sloping land, the scanty soil, the short growing season, and the dense forests that may be difficult to clear. Grazing and forest industries may be of some importance.

When a mountain region has reached maturity, little of the original upland surface remains and the divides are narrow ridges, useless for occupance. The larger rivers have begun to develop flood plains, and it is on these and the gentler lower slopes of the mountains that man settles. Upper slopes may provide timber and summer grazing of livestock. The population is widely scattered, since families can find support only on the small plots of available lands. Given time enough, even high mountains attain old age. Then the rivers are easily navigable and the erosional plain, having little relief, can be crossed and cultivated almost everywhere.

In an arid climate, mountains also pass through a cycle of erosion, but the debris eroded from the uplands by torrential floods is dropped around the bases of the mountains where it forms extensive alluvial piedmont plains instead of being carried away to the ocean. The mountains thus disappear in part by erosion of water and wind, and in part by the filling of adjacent lowlands by debris coming from the mountains themselves.

Mountains as Barriers. The effectiveness of mountains as barriers depends on their height and length and the arrangement of the ridges that form them, as well as on the altitude, character, and number of passes that penetrate them. Mountains may be barriers to travel, to commerce, to invasion, and to rainfall and temperature.

Mountains may cause the precipitation of so much rain on their windward slopes that deserts will occupy most of the land to leeward, as the desert of Nevada lies east of the Sierra in the prevailing westerly winds. Mountains like the Alps and the Sierra Nevada may protect land to leeward against freezing cold arctic air, thereby permitting the growing of subtropical crops like oranges on their protected slopes much farther from the equator than would be possible otherwise. Mountains, by this effect on climate, may prevent the spread of natural vegetation and animal life.

Mountain ranges form excellent natural boundaries when they are high and rugged enough to form a good barrier. The Pyrenees form a fairly satisfactory political boundary between France and Spain, although the boundary line does not always coincide with

the main divide of the range. The mountains of Scandinavia form a natural barrier between Norway and Sweden, as do the Bitterroot Mountains between Idaho and Montana. Mountains, when forested, are much more difficult to cross than are bare ranges. Thus the Appalachians are comparatively low, but their densely forested ridges formed an important barrier against western exploration and settlement from the Virginia and Carolina colonies.

Mountain Barriers and Passes. When mountains are barriers against travel and trade, passes through the mountain barrier become of paramount importance. The utility of a pass depends upon its altitude, its elevation above the lower land at either end, the length of time during the year in which it is free of snow and open to travel, the roughness or other difficulty afforded by the terrain, and the type of region it serves at either end. To be widely used by man, a pass should connect important settled regions. Some passes are of great historic interest.

Passes in Europe. In Europe the Alps rise high above the plains of northern Italy, and the passes afford the only means of reaching northwestern Europe. The historic St. Bernard pass has now lost some of its former importance because tunnels through the Alps carry the railroad routes that transport most of the freight, passengers, and mail. Cities thrive at the ends of passes, from which trade routes diverge and goods are distributed. Thus Turin has connections through the Mont Cenis tunnel to Lyon, France; and from Milan the long Simplon tunnel offers access to central Europe. The St. Gotthard route is occupied by another railroad which has tunneled under the pass. The Brenner Pass is of much interest; it lies north of Venice and affords a comparatively easy route from the Adriatic Sea into Austria, Germany, and the Baltic coasts (Fig. 167). Between the North German Plain and the Danube Basin lies the Moravian Gate.

Passes in Asia. The highest mountain barrier on earth is the Himalaya range north of India. The most important route from the northwest into India comes from Afghanistan through the Khyber Pass. In addition to its use as a trade route, the Khyber Pass from the earliest times down to the present has served as a route for the invasion of India by fierce nomads from the steppes and deserts of central Asia, attracted by the wealth and fertility of India. The passes north and northeast of India are so very high or otherwise

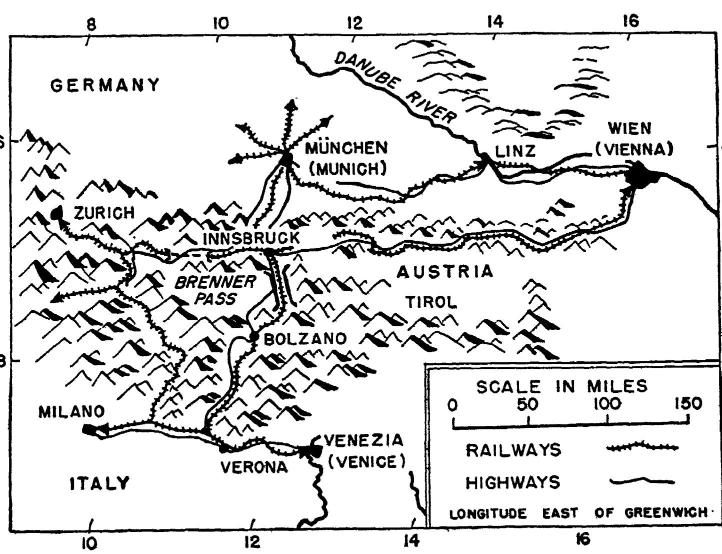

FIG. 167. Brenner Pass as a transportation corridor.

difficult that they have served as routes for only a few hardy traders. Large armies have invaded India only from the northwest where the passes are lower and easier. Two important passes from China are the Nankow Pass leading from Mongolia west of Peking and that from the Wei Ho Basin into the Tarim Basin—the Jade Gate.

Routes Related to the Rocky Mountains. In the western United States, both the Rocky Mountains and the Sierra Nevada–Cascade Ranges form serious barriers to transportation. Railroads have sometimes preferred to build around the mountains, as the Santa Fe and Southern Pacific have built south of the Rockies. The Northern Rockies have few east-west trending valleys. As a result, all through transcontinental railroads crossing Montana come together at Spokane at the western end of the only easy route across the Northern Rockies. Denver has suffered under the handicap that the passes west of that city are so high and troubled with heavy snow that railroad building was very expensive and operation very difficult. The railroads therefore went from Denver northward through the open country of Wyoming or southward to the Grand Canyon of the Arkansas River, which provided the most practical route across the high Rockies. Recently the city of Denver, feeling the need of overcoming the natural handicaps to transportation, raised the required funds and completed a tunnel through the Rockies westward to give a shorter and more direct route to Salt Lake City.

Mountains as Boundaries and Refuges. Mountains appear to be excellent natural boundaries. As a matter of fact, they serve as political boundaries less frequently than is generally supposed. The continental divide of the Rocky Mountains, for example, is utilized as a state boundary for only a short distance between Montana and Idaho. Mountains and hills may serve, however, as places of refuge. Defeated peoples often find a haven in mountains and hills after an invader has driven them from the fertile lowlands. Thus the original Britons sought refuge in the mountains of Wales and Scotland and the sterile peninsula of Cornwall, and one of the oldest peoples of Europe, the Basques, live in the Pyrenees on both sides of the political boundary between France and Spain. Other descendants of very ancient inhabitants of Europe are found in Albania.

Because of lack of resources, mountain people have difficulty making a living and in the past often raided the fertile lands nearby for cattle and grain. Thus England suffered from raids by the Welsh and Scots for many years. The Christians in Spain, defeated by Moslem invaders, fled to the Pyrenees for refuge. From this haven for centuries they harassed the lowlands occupied by the Moors and gradually won back their ancestral land from the invaders, completing the conquest late in the fifteenth century. The mountains breed men who are hardy, bold, and able in hunting and fighting. Sometimes they become so numerous that, united under a good leader, they are able to conquer the larger populations living on nearby lowlands. Thus the mountain dwellers in the highlands north and northeast of Iraq have emerged from their mountain fortresses several times in history and conquered the less warlike agriculturists of the plains.

Mountain and Hill People at Home. Because of their isolation, mountain people oftentimes exhibit close relationship to their environments. Their houses are built of available native materials, usually stone or wood. In forested snowy mountains the house is made of logs with a steep roof to shed snow. Often the less steep roofs are covered with stones so that high winds will not destroy the structure (Fig. 168). In mountains around the Mediterranean and in the high Andes, where timber is scarce, stone finds more frequent use in housebuilding. Generally mountain dwellers live in villages for mutual aid and protection. Difficulty is often experienced in raising or making products for sale, some of which are desired in order to purchase essentials that are not naturally available. Some

FIG. 168. A typical house of the hill and mountain lands of southern Germany. Note the wide overhanging eaves and the use of heavy rocks to protect the low-pitched roof from high winds and sliding snows.

mountain communities specialize on wood carving, toymaking, clock manufacture, the rearing of pets, lacemaking, and other things, in all of which the time element, of which mountain people have an ample supply, is more important than the cost of raw materials. Improvements in transportation may make it cheaper to import the grains required for food in which case the mountain grain fields may be abandoned or changed to hay production.

The Southern Highlanders. The southern highlanders in the Appalachians show the result of isolation in their environment. Nearly all are descended from English, Scotch, and Irish ancestors, since few later immigrants have cared to enter the mountains. Difficulties of transportation for more than a century compelled the people to live an isolated self-sufficient life in their remote mountain homes. This helped the mountaineer trend toward conservatism in culture and habits. Archaic English words in common use before the Revolutionary War survive among those who settled in the southern Appalachian region. Old customs and manners of life may be extremely persistent. A mountain man has difficulty in raising products for sale abroad and can buy little from outside. He must build his own house of logs or stone. Women make their own cloth from home-grown wool and flax. Most of the furniture and other possessions are made by members of the family. Furs and leather made from the skins of their domestic animals were commonly used for apparel. Today the tourists who followed highway improvement, the development of coal mines, and utilization of the forest are causing rapid changes among the inhabitants of "Appalachia."

Generally mountain people, whether in the United States or abroad, raise a variety of crops instead of specializing on one or two things, since crops are raised for sustenance and not for sale. Until modern transportation by highway and railroad began to penetrate the mountains, and schools and hospitals were established, the people lived largely without education, medical aid, or effective government. The people are hospitable once their confidence has been gained, although somewhat suspicious and shy of strangers. In this respect, mountain people somewhat resemble desert and steppe nomads. A mountain man must be hardy, fearless, and a Jack-of-all-trades, since desired things must usually be made of local materials rather than purchased from outside. Health conditions are naturally favorable; but, because of the difficulty of securing proper medical attention, mountain dwellers often have a high death rate and suffer from sickness needlessly.

With the construction of highways, the establishment of schools, and the resulting increased contact with the outside world, the old customs and culture decline, and the mountain people adopt much the same manners and culture as those of the balance of the country's population. Such changes have now taken place over most of the southern highlands of the United States.

Mountains as a Source of Emigrants. Because of lack of opportunity, mountains soon become overpopulated. Generally the more progressive and ambitious men and women leave their mountain homes to seek their fortunes in the lowlands and cities. During the nineteenth century the highlands of Scotland lost much of their population to the industrial cities of Great Britain and by emigration abroad. Certain villages in the Italian and French Alps have lost more than half their population within a 50-year period. Some of the villages of the Canton Ticino in Switzerland regularly supply waiters for Parisian restaurants during the tourist season; during the rest of the year, the men return to their mountain homes to carry on agricultural activities.

The hilly Appalachian Plateau, southern Appalachian Mountains, and the Ozarks in a similar way have supplied labor to industrial cities and more favored farm lands in the United States. One of the important exports of many mountain regions is men and women. Many of these immigrants succeed well in their new homes because of their industry, strength, and hardiness.

Mountain Countries. Politically isolated mountains frequently contain small independent states. Because it is difficult for outsiders to penetrate the mountain masses, the inhabitants are aided by nature in the defense of their homes. Thus in Europe the tiny independent countries of Andorra, Liechtenstein, and San Marino are in rugged mountain regions. Most Swiss live in the valleys and lower land rather than in the high Alps, although the mountainous character of the country aided the cantons in their movement toward independence and defense against the outsider. Nepal and Bhutan on the southern slopes of the Himalayas occupy regions that are difficult to penetrate, and thus they remain independent political entities. Even where a mountainous area has not separated from a lowland with which it may be associated, political difficulties frequently result from the different problems in the two areas. Thus the plateau regions of eastern Kentucky and Tennessee generally are at "political outs" with the richer inhabitants of the Bluegrass and Nashville basins lowlands.

Mountain Climates. Mountains affect climate in several ways, and they may have climates that are distinctly different from those on adjacent lowlands. They sometimes also separate regions with quite different climates on either side of a mountain barrier.

Temperature. The insolation received by mountains differs from that of neighboring lowlands because (1) less density and greater purity of the air in higher altitudes permit the passage of more of the sun's radiation (Fig. 169); (2) rays of light that are oblique on lowlands fall directly on the slopes of the highlands facing the sun. Highlands may receive more insolation than neighboring lowlands, but the average temperatures decrease with elevation largely because the less dense air allows rapid loss of heat by radiation

FIG. 169. Palomar Mountain observatory, San Diego County, California, at an altitude of 6,126 feet. This structure houses the 200-inch telescope. The site was selected because of the exceptional clarity of the air and the distance from city lights which might interfere with nighttime observations.

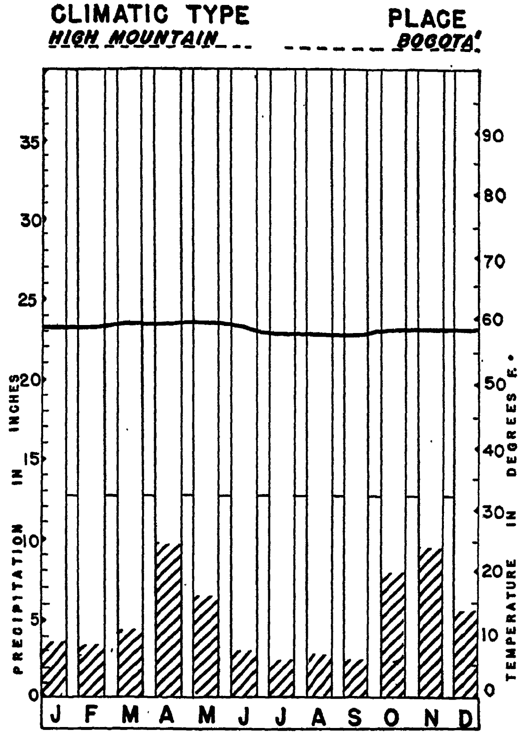

FIG. 170. Climatic graph for Bogotá, Colombia. Weather stations located at high altitudes in low latitudes usually have remarkably even temperature means throughout the year—an isothermal condition that tends to provide a monotonous temperature. This, however, is offset by considerable daily (diurnal) range with warm daytime and below-normal nighttime temperatures for their latitude. Precipitation, either as rain or snow, is variable in amount.

from the highlands (Fig. 170). In mountain valleys sunny slopes have advantages over shady slopes, for both crops and places of residence. In the Alps, Pyrenees, and other ranges, sunny slopes are preferred for homesites by a large majority of the people and for the location of most of the farm, while the shaded slopes find more use for forests and pasture lands.

Mountain peaks usually are exposed to strong winds, since they reach altitudes at which wind velocities are greater, but mountain valleys and leeward lowlands may be protected by mountain masses from damage by severe winds. Long valleys often control wind direction locally, since the winds blow with least resistance up and down the valleys. Convectional movements of the air commonly occur in mountains. During the heat of the day, air expands from the lowlands toward the mountains, forming a day breeze. After sunset, the mountain summits quickly lose much heat by radiation. Air cools and contracts as a result, and then the denser air descends toward the valleys and lowlands, forming the night or mountain breeze, as described in Chap. 4.

Temperatures among high mountains may be too low at night to permit the growth of any but hardy plants. Likewise some valley floors and lowlands may experience late frosts in spring and early frosts in autumn, resulting in a growing season too short for fruits and certain other crops. On the hillsides between the frosty lowlands and the cool uplands, however, there may be a thermal belt having a long growing season suitable for growing fruit. These thermal belts may be only a mile or two wide, lying between differences in elevation of only a few hundreds of feet, but within their narrow zone relative freedom from frost is enjoyed. Familiar examples of such thermal belts are found in North Carolina east of the Appalachians, in the foothills of the Sierra Nevada along the San Joaquin and Sacramento valleys, and along the southern slopes of the Alps. They are particularly associated with the presence of piedmont alluvial plains (Fig. 144), though any foothill location may have this so-called "frostless belt." Citrus fruits mature along the shores of mountain lakes in northern Italy on the southern slopes of the Alps, as at Lake Maggiore, which lies in the latitude of Michigan. Although the presence of lakes helps to prevent frost, the growing of citrus fruits in this northerly location is made possible in part by the protection the mountain masses afford from the cold winds of the interior of the continent. In a similar way the Himalayas protect the plains of northern India from invasion of cold air masses from the interior of Asia. High mountains lying north of Florida would be of great benefit to

that state, since they would protect the peninsula entirely from frost, and tropical products could be raised everywhere in the area.

Rainfall. Mountains exert most important climate effects when their length extends at right angles to prevailing wind directions. Thus the Sierra Nevada and Cascades stretch for hundreds of miles across the path of prevailing westerly winds in their latitudes. Exceedingly heavy rains and snows occur on the westward slopes of these ranges, but the winds descending to the eastward have been robbed of their moisture and become drying winds of the deserts. Mountains rising in the zone of the trade winds show astonishing differences in rainfall between their windward and leeward slopes (Figs. 47 and 139). Thus the mountain summits of Kauai, one of the Hawaiian group, have a rainfall of nearly 450 inches a year, while the rainfall decreases to less than 20 inches 20 miles westward from the crest down the slope of the mountains. The deserts of northern Chile and the coast of Peru (Fig. 54) result in part from the effect of the Andes in robbing the trade winds of their moisture so that the rains fall on the eastern side. As a result of differences in rainfall, the windward sides of mountains often support dense forests, while grasslands and even scanty desert vegetation may appear on the leeward sides. On the western side of the Cascades, great forests are supported in which very important lumbering operations are carried on. East of the mountains, agriculture predominates, with grain raised by "dry-farming" methods. Fruits and alfalfa are produced by irrigation, and livestock is grazed on the land unfit for farming.

The Latitude Factor. The use of mountains depends to a considerable degree upon their latitude. In a mid-latitude zone the greatest number of people live on plains and lowlands. Only four cities above 100,000 in population exist between the Pacific coast seaports and the cities in the humid interior lowlands of the United States (Denver, El Paso, Salt Lake City, and Spokane), although this area includes nearly 40 per cent of the total extent of the country. Three out of five persons in the United States live below 1,000 feet in elevation, although nearly three-fourths of the nation lies above this altitude. The same thing is true in those parts of Europe where the great cities are nearly all on seacoasts or plains that are under 1,000 feet in elevation. Madrid and Munich are the most populous exceptions. In Asia most of the Chinese and Japanese live on the deltas and flood plains of rivers. Mountains in mid-latitude zones, then, support only a scanty population; and, because most of the people in these mountains live in the valleys, there is a great inequality in distribution of population in mountain areas. Even in wet-and-dry tropical monsoon climates like India, one-third of the large population lives in the deltas and valleys of the Ganges River alone.

An entirely different condition of affairs prevails in the rainy tropics, however. Tropical lowlands are so hot and humid, so densely forested, and so stricken with insect pests and disease that men are repelled and prefer high plateaus and mountains as places of residence. Important Indian civilizations developed in the mountains and plateaus whose climate was tempered by altitude in Mexico, Colombia, and Peru, located within the tropics. Except for coastal seaports, all the great cities of tropical America are situated on plateaus or in high mountain valleys. In Ecuador, Peru, and Bolivia men prefer to live at elevations of from 7,000 to 12,000 feet; for example, Quito lies 9,350 feet and La Paz over 12,000 feet above sea level. Temporary huts of shepherds have even been found at elevations exceeding 17,000 feet. Such elevations in high latitudes are utterly useless to man because they lie above the snow line.

In high latitudes only the lowlands find use by man, because the mountains are generally covered with snow fields and glaciers. Sometimes the statement is made that in the tropics every climate can be found on going from sea level to the tops of snow-capped

mountains, corresponding to those which would be experienced in going from the equator to polar regions. With regard to average temperature this is true, but the equatorial regions lack the extreme range in temperature between winter and summer of high latitudes; only moderate changes occur in daily temperatures throughout the year. A snow-capped mountain in equatorial Africa, then, has somewhat different climate from that on the glacier-covered mountains of Alaska and Greenland, even if the average temperatures are about the same.

Snow Line. Permanent snow fields begin at altitudes around 18,000 feet under the equatorial sun and may descend to sea level in polar regions. The height of the snow line depends upon the amount of snowfall and the rate of evaporation. The latter is affected by the temperature, amount of sunshine, cloudiness, and wind movement, as well as by the direction of exposure to the sun.

Glaciers. When snowfall exceeds snow melting and accumulates year after year, the snow first changes to a granular condition and finally into snow ice. Glaciers result from this consolidation of snow into ice, and they carry the frozen water from higher to lower elevation. Glaciers profoundly affect the mountain valleys that they occupy by grinding off any loose and weathered rock material, polishing the surfaces of the bedrock, transporting the rock debris, and finally dropping the material into irregular heaps and ridges called moraines wherever the ice melts.

The surface of a glacier toward the end of

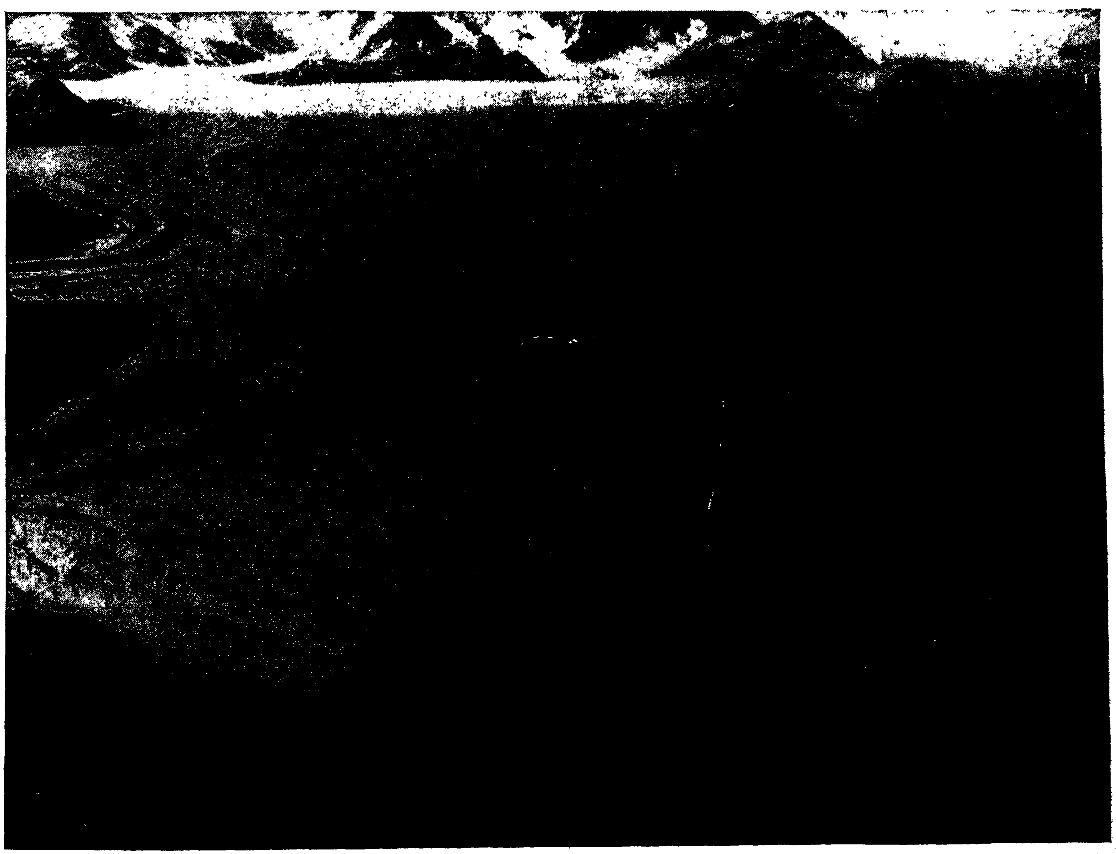

Fig. 171. Seaward end of Columbia Glacier near Valdez, Alaska. Note the extensive development of medial and lateral moraines and the icebergs in the foreground. (*Air Force photograph.*)

summer, when the snow has melted under a summer sun, always appears dirty from the rock debris that has fallen from the cliffs above or has been scoured from abrasion of bedrock or in other ways. The ice melts on top and within the glacier as well as at the end. From passing over irregularities in the valley, the glacier usually shows great cracks called crevasses, which serve as conduits to lead the melt water into a massive channel under the ice, from which a full-fledged river emerges at the lower end of the glacier. This stream is loaded with finely ground-up rock which gives the water a typical milky appearance. Much of this debris is deposited in front of the melting ice down the valley, filling it up and producing extensive valley fills. Great heaps of stones mixed with finer clay accumulate along the sides and at the end of the ice as it melts, forming the lateral (Fig. 171) and terminal moraines.

Former Glaciation. In the past, glaciers were much more extensive than today, and many mountain valleys show evidence of this prehistoric ice work, although now the glaciers in the mountains are only small remnants of the vast sheets that once existed. Nonetheless glaciated valleys can be easily recognized. Moving glacial ice erodes the ends of all projecting ridges and spurs and thus, by cutting off the lower parts of the mountain spurs, changes a normal V-shaped valley into a broader U-shaped valley (Fig. 150) having smooth slopes and a straightened course. Tributary valleys oftentimes end high above this new valley floor which was lowered by glacial erosion. From these hanging valleys, waterfalls may plunge into the main valley, as at Yosemite Falls. The rock walls lack soil and may be almost devoid of vegetation. Man utilizes mainly the outwash deposits and moraines, where they are not too stony for agriculture. Glacial gouging and deposition of debris frequently form lake basins (Fig. 151) that add to the beauty of the scenery. Above the level reached by the valley glaciers, the upper parts of the mountain spurs may have been little affected by glacial erosion. Here are meadows of value for grazing. The Swiss call such mountain meadows *alps,* a name now applied to the entire mountain system.

Hills

Hills merge with mountains and plateaus at their upper limits and with plains on their lower borders. Their occupance and use by man likewise fall at an intermediate position between human activities of the higher and of the lower land forms in that hills have relief features partly resembling those of both mountains and plains. In general, regions with a local relief between valley bottom and hilltop ranging from 300 to 500 feet or more in altitude are considered hilly; if the magnitude of the difference in elevation greatly exceeds 1,000 feet, the region is usually called mountainous if it is rugged, or a plateau if its upper surfaces are level to rolling (Figs. 139 and 172). Local custom and authorities differ so widely on the terminology that no hard and fast rule can be stated in the matter of defining hill lands.

Origin. Hills result from the erosion of uplands that may have been mountains at one time or from the erosion of plateaus or plains of sufficient height that their reduction will result in a difference of local relief, as described above, with only remnants of their original surface remaining undissected. In mountains the hill stage can be expected in late maturity when the mountain summits are much reduced in elevation. In a plateau the region is called hilly when in maturity the valleys crossing the area have become so wide that slopes rather than the original surface dominate the landscape. In general the same conditions would be true of plains, provided that the original plain was of such elevation that the local relief developed there by erosion attained a difference of elevation of several hundred feet. Otherwise an eroded plain

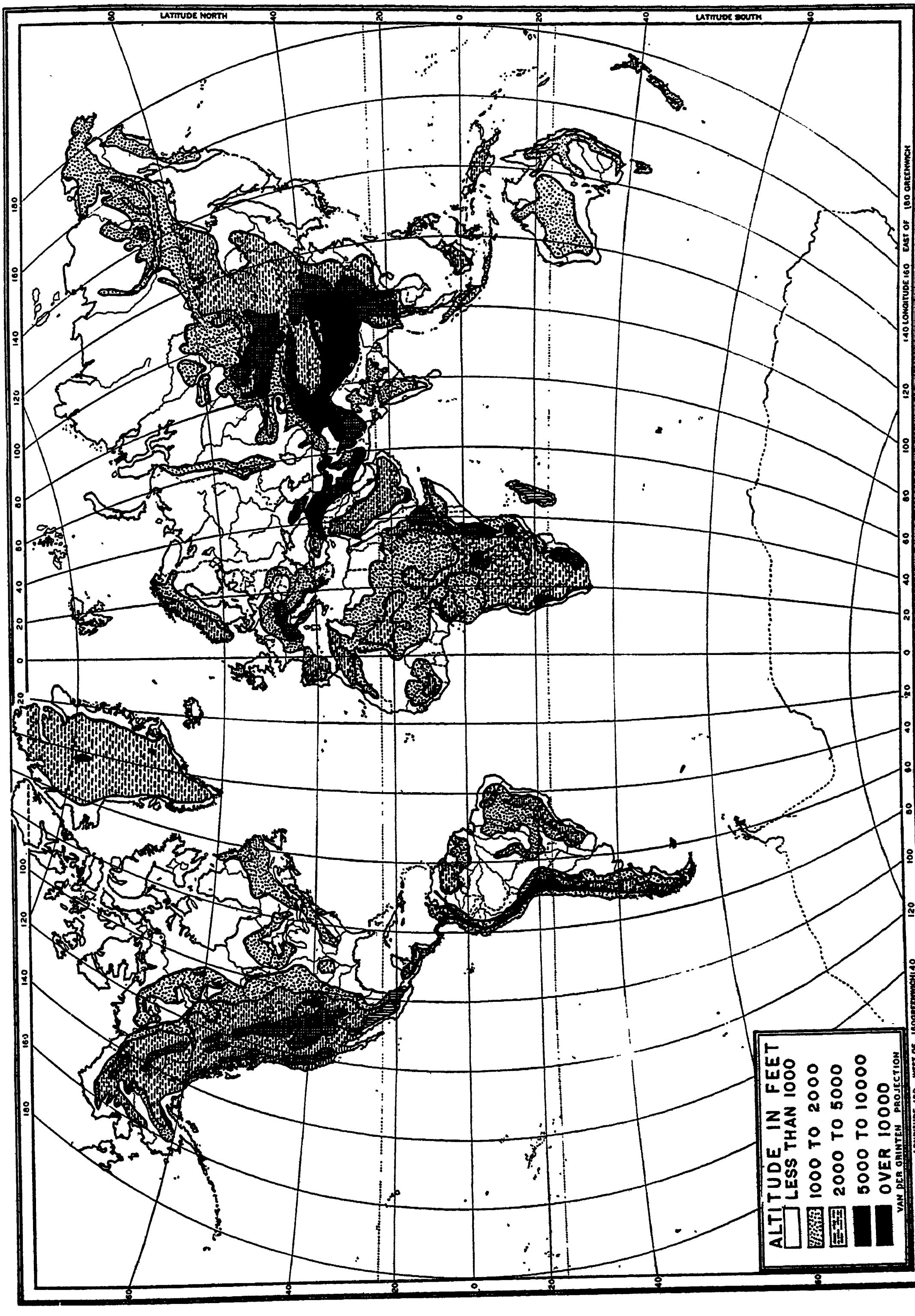

FIG. 172. Altitudes of the earth's land areas. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

of this type would still be considered a plain.

Human Relationships to Hill Land. Much of what has been said of mountains is also true of hill lands, although on a reduced scale. Hills lack sufficient altitude to act as climatic barriers of importance, but the ruggedness of their surface is a distinct handicap to the construction of railroads and highways and to the use of the land for farming. Hill people sometimes live in an environment as isolated as that of mountain people. Hills provide much protection when defense is needed, and they are invaded with difficulty by warlike neighbors, though this was not true of the hilly Ardennes region of Belgium and France during the early days of the invasion of France in the last war. Hilly land situated in humid climates originally had an excellent forest cover; the utilization of such forests is still of great importance to the people who live in these regions. Grazing and subsistence farming are other industries.

As a general rule, hill lands fail to supply their residents with raw materials or minerals in sufficient quantity to lead to advancement in manufacturing or to the accumulation of large amounts of wealth. The Welsh, the Irish who live in the western counties of Eire, and the Italians who dwell in the hilly Apennines are barely able to make a decent living for themselves; and their living standards are noticeably lower than those of the people in the more fertile and productive lowlands around them. On the other hand, if hill country possesses some resource that is regarded as valuable by the outside world, then "hillbillies" may have a source of additional income if their resources are exploited. Hill regions of West Virginia and western Pennsylvania and eastern Kentucky, for example, have valuable beds of bituminous coal that brought wealth to the local residents as the mines were placed in operation. These coal beds outcrop on the hillsides, and mining can

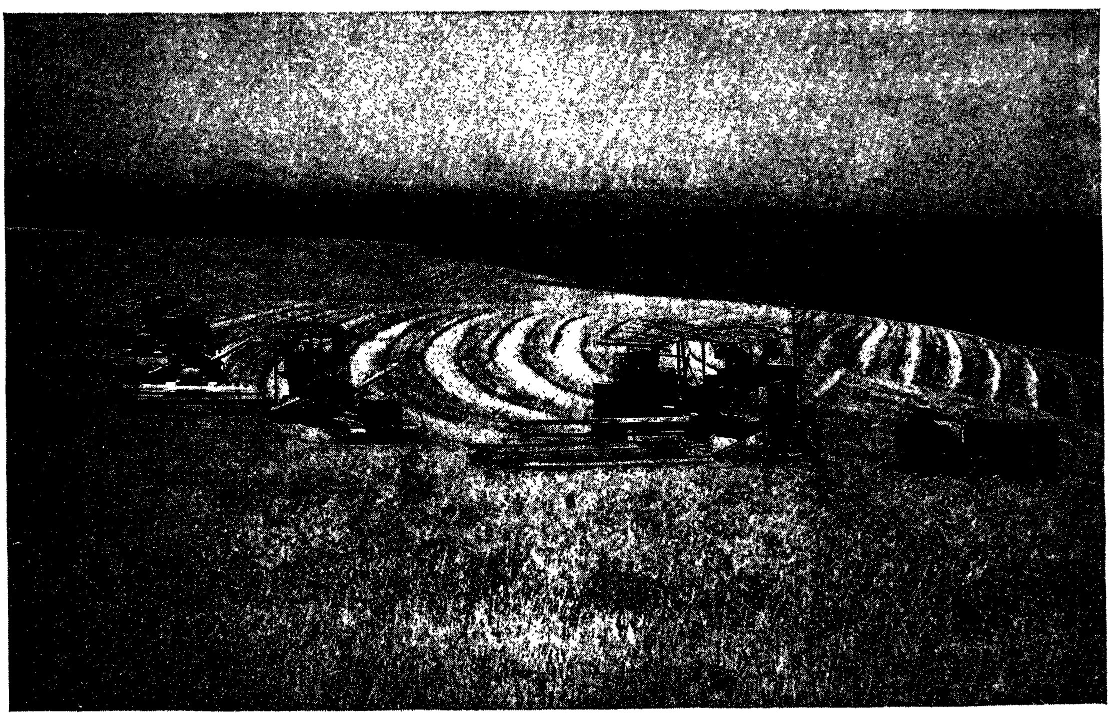

FIG. 173. Wheat fields of the Pacific Northwest, with harvest under way by four combine harvesters. This is large-scale farming. (*Photograph by Brubaker Aerial Surveys, used by permission of the Leonard Delano Studios, Portland, Oregon.*)

therefore be done in many places by entering from a side hill along some creek whose valley has truncated the stratum of coal. Tunnels driven in from these hillsides are cheaper than sinking a vertical shaft, and the coal thus mined can be delivered by gravity conveyors directly to railroads in the valleys below the mine entrance.

The erosional processes by which hill lands are formed through dissection usually remove soils as they form on the hilltops and slopes, and the evacuation of these soils by means of running water may be rapid. The slopes and the summits normally may lack deposits of soil of any great depth, and as a rule the meager soils that remain in place on the slopes are of low fertility if the owners try to farm them. Agriculture in hill lands normally does not contribute to economic stability of the farmers of these regions because of the poverty and thinness of the soil conditions. This is true of many backwoods farmers in the Ozarks, for example. On the other hand, some hilly regions are fortunate enough to have excellent soils of a high quality that will make for successful farming operations. This is true in the Palouse Hills of eastern Washington (Fig. 173), the Loess Hills of northern China, and some hilly areas of central Europe. Unless great care is used in farm practices, however, hill farms are more subject to the evil effects of rain-water erosion than are lands having lower angles of slope. In too many cases, both in this country and abroad, the farm land of hill regions has suffered severe erosion (Fig. 174), a matter that becomes all the more serious when it is remembered that the original extent of good farm land in most hill sections is small and that the loss of the soil increases the difficulties of the farmers. Some hill lands near the southern Appalachians, the Mediterranean Sea, and northern China have been made almost worthless by serious soil erosion.

In the hill regions, the principal towns and villages are often located at valley confluences

FIG. 174. Effects of soil erosion on the appearance of a once-prosperous Ohio farm. Neglect of proper principles of cultivation has caused bankruptcy of many farms of this type. Topsoil of the pasture behind the barn has been completely removed by erosion, and there is little topsoil remaining on the cultivated fields. (*Photograph courtesy of the U.S. Soil Conservation Service, Department of Agriculture.*)

or at the ends of passes that traverse the rough country. Few large cities are found in hill land; indeed there are not sufficient resources to support many people, and the total population is usually smaller than on fertile plains having similar climatic conditions.

Utilization of Mountains and Hills

Forests. Most mountains and many hills support forests of considerable extent. This was suggested in Chap. 11, where it was pointed out that the use of a place name, Schwarzwald, signified both mountain country and forested country. The same condition prevails in the use of some other names; Transylvania, a wooded and mountainous region of Rumania, was the name applied to that region, and in the United States the name Pennsylvania signifies not only the original owner's name but the fact that originally much of that state was forested, particularly in the western hilly parts.

Zones of Vegetation. Frequently a zonal arrangement of vegetation, ranging from the lower elevations to the mountaintops, can be recognized; but the character of the vegetation changes slowly from one zone to another, depending upon increase of altitude. It may also vary widely as the result of differences in type of bedrock, soil, relief, or exposure to winds. The temperature, rainfall, and length of growing season are only a few of the many factors that affect types of vegetation. In deserts there is an upper and a lower tree limit, the former determined principally by temperature and the latter by rainfall. Thus belts of forested land may surround mountains, as in the San Francisco Peaks of northern Arizona, whose lower slopes are treeless deserts and whose summits are alpine meadows.

The Tree Line. Vegetation zones may have their own peculiar species and varieties of animal and insect life, as is illustrated by the summits of many mountains in the United States; here at the upper heights the plant life and the insects are similar to those living along the shores of Hudson Bay. Toward the upper limit of growth, trees become dwarfed and sometimes assume grotesque shapes (Fig. 56). A tree whose age is measured in centuries may be only a few feet in height, though its branches may spread widely over the ground. Such trees are buried in many feet of snow in winter and experience a growing season that can last only a few weeks in summer.

On some mountains the tree line will be higher on the windward side because of heavier rainfall in that quarter. Usually the tree line is lower on the northern slopes of mountains in the Northern Hemisphere because of the nature of the exposure, which of necessity will be more severe on the northern side.

The summits of many mountains are free of tree growth. This may result from exposure to wind and to very sudden changes in temperature, especially on the sunny southern slope of northern mountains. Variation in the elevation of the tree line in the Alps is from 5,000 to 8,000 feet; the 3,000-foot difference is partly the result of temperature contrasts, different exposure to the sun, the duration of the snow cover, and the amount of rainfall. Other factors include the groundwater conditions, soil depth, and rate of evaporation. Even the character of the bedrock is important. Trees generally extend to higher altitudes on soils that have been formed from granite than on those formed from limestone, since the latter allow rapid seepage of ground water. Plants on mountain meadows closely follow the melting of the snow and must mature in the brief summer and on the small amount of water that they can secure from the very pervious rocky soil. In this they resemble the plants on the arctic tundras.

Forests and Water Conservation. The relation between forests and the consumer of water is very close. A map of irrigation districts of the western United States (Fig. 228) shows that practically all secure their water supply from forested mountains. It is well

known that erosion of the steep mountain slopes becomes very rapid when forests have been destroyed by fire, careless lumbering operations, or overgrazing. Increased runoff sweeps the scanty soil away, making reforestation very difficult. In addition, the coarse debris may be dropped on tillable land in the valleys. Rapid runoff may cause springs to dry up and streams to cease to flow except as intermittent floods. Terrible examples of the results of deforestation in mountains can be found in northern China and in many of the mountains adjoining the Mediterranean Sea.

In the western United States, adjacent valleys—one still forested and the other devastated by fire—have many times shown the expected results after heavy rainfall occurring in each drainage basin; destructive floods have come from the deforested area while the forested valley has had its emergent stream remain clear and undamaging. The forest with its accumulated debris slowed the runoff and prevented erosion, and the emerging stream was relatively clear without any destructive flood; while the rainfall in the deforested area ran off so quickly that little water sank into the ground. Terrible floods resulted, and the stream was filled with coarse debris, the deposition of which might cover and ruin fertile arable land along the lower course of the stream. Snowbanks under cover of trees melt more slowly by several weeks than those in treeless places, and thus they prolong the flow of streams and the period of irrigation. The profitable continuance of farming operations in deserts adjacent to mountains and in mountain valleys generally necessitates the preservation of forests.

Logging Costs. Forests in mountains are relatively inaccessible, and lumbering operations there are somewhat more costly than on lowlands. When more accessible forest resources have been exhausted, however, the supplies in the mountains begin to be used. This utilization is proper if care is used in logging so that, by selection, only mature trees are cut and the young growth is left as protection against excessive runoff and as a provision for future tree growth.

Mountain and Hill Agriculture. Because of the lack of large areas of level fertile land, the problem of raising a food supply is usually one of considerable difficulty in hills and mountains. First the most level land along the streams will be cleared and cultivated. Then the more level hilltops, if they are not too high, and the gentler slopes on the shoulders of the hills will be farmed. Finally even steep hillsides, with slopes as great as 30 to 40 degrees, may be cultivated. Erosion will be so rapid on these slopes that a field will produce a crop for only 3 or 4 years. Then it must be abandoned and more land cleared. Such practices naturally result in great harm to forests and ultimately to the downstream portion of the drainage basin.

Sometimes people who lack tillage land will laboriously terrace mountainsides and raise crops on the narrow terraces whose soil is supported by rock walls, as in the vineyards along the slopes of the Rhine Gorge and the *huertas,* as the Spaniards call their vineyards and orchards clinging to the steep Mediterranean coast near Valencia. Even primitive peoples may raise crops in remote mountains on remarkable terraces. Certain Malay tribes in interior Luzon raise rice in this way. Only a little terracing has been done in the United States, primarily because this nation has great areas of land, and economic pressure has not yet compelled us to use these methods of conservation. In future we can expect more work to be done along this line.

Livestock Industry. Lack of tillable land and considerable areas of available grassland in mountains generally encourage the livestock industry. Furthermore animals can be driven to market over poor trails on which it is impractical to attempt to haul farm products. Limiting factors in the complete utilization of mountain grasslands are the long period of winter feeding required in cold weather and the scarcity of land available for raising hay. Cattle have an advantage in that they produce both meat and dairy products.

Dairying in the Alps. Formerly, and to some extent today in the Alps, the inhabitants occupied three or four houses at various times of the year. The winter house was in a valley where the animals might be fed conveniently; another house was in the lower alp pastures for use in late spring; and a house in the high mountain pastures was used in July, August, and September (Fig. 175). Herders and dairymen accompanied the herds to the high pastures and there made the milk of the cattle and goats into cheese, which was then brought down in the autumn for consumption in the lowlands. Some of the villagers remained at home to gather hay, grain, and fruit crops cultivated in the valley. Distances from the high pastures to the home village made the return of animals each day, as well as the transportation of the milk itself, highly impractical. This periodical movement is called *transhumance.* It should be noted that transhumance utilizes permanently built houses, whereas the nomad uses a portable house or tent. In modern Switzerland, immature and beef animals are taken to the mountains, but milch cows or goats are kept at lower levels. As a result, less cheese is now made in the high Alps. Most of the cheese made for export or consumption is produced in plants in the accessible valleys, indicating that, with improvement of transportation, utilization of resources may also change.

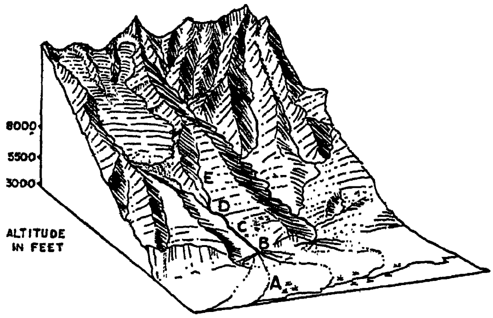

FIG. 175. Transhumance in the western Alps. (*After R. Blanchard.*) *A.* Meadow lands, pastured at all seasons. No permanent villages at the lowest levels because of flood and frost threats. *B.* Vineyards cultivated in April and May. Permanent year-around village settlements making extensive use of hydroelectric power. *C.* Grain fields, sown with rye, oats, and a little wheat. Permanent villages. Most of the cultivation is done in May. *D.* Villages, or *montagnettes,* occupied during June, July, and August. Small fields of potatoes are characteristic of farming at this altitude. *E.* Temporary dwellings, or *montagnes,* occupied by mid-June. Hay is cut in the mountain meadows (alps), and grazing continues until October 1 when the cattle are returned to *A.* There is no agriculture or tillage at this altitude.

Livestock in Mountainous Regions of the Western United States. In the western United States, flocks of sheep and herds of beef cattle are commonly pastured during the summer in mountain meadows (Fig. 176); in winter they feed upon the available wild range and hay in the lowlands. The animals are accompanied by a few herders, who represent a modified form of transhumance, without the permanent mountain hut of some European herders. This type of transhumance is common practice along the California coast south of San Francisco and Monterey, where descendants of Italian Swiss dairymen still take their cattle to the upper pastures during the dry summers, where they can find green forage. Sheep and goats may be preferred over cattle in some mountain regions, since they can utilize herbage that is less nutritious and can crop the plants nearer the ground than cattle can.

Tourism in Mountains. In recent years it has become the fashion for lowlanders to visit the mountains for health and pleasure. Large hotels and entire towns have been established to cater to summer and winter tourists and health seekers (Fig. 177). St. Moritz, Lake Placid, Banff, Sun Valley, and Colorado Springs are a few examples. Millions of dollars are spent annually in Switzerland by tourists. Thousands of people in that land find their entire support in catering to the visitors. The resorts need not be particularly high in altitude, but without exception they must have some particular attraction for their visitors; this may depend wholly or in part upon the characteristics of mountain scenery or upon the pleasant summer temperatures that may be found in mountains. Resorts on Mount Rainier and Mount Hood, for ex-

FIG. 176. Flock of sheep pastured in the Blue Mountains of eastern Oregon. This view is typical of many pasture lands and ranges throughout the semiarid western United States.

FIG. 177. Grand Tetons in Grand Teton National Park, Wyoming. The pyramid peaks were shaped partly by glacial erosion. The buildings are part of a "dude ranch" that keeps cattle and also entertains tourists. (*Photograph by Crandall.*)

ample, appeal to tourists on the basis of their impressive scenery, the presence of accessible glaciers, the mountain forests, clear atmosphere, and cool summer temperatures.

Minerals in Mountains. Some mountains, especially those containing intrusive igneous rocks, have important mineral deposits. Others of sedimentary rock may contain coal. The utilization of these mineral resources may lead to the development of large local centers of population in places where otherwise only a few herders might find support. Most of the large western cities at high elevation in the mountains—Butte, Leadville, Cripple Creek—are mining towns. Hundreds of smaller settlements are scattered through the western mountains of the United States. A mining town is generally a short-lived settlement. After a few years, or a few generations at the outside, the mines are worked out, and the town associated with them becomes a ghost city unless some other means of support can be developed to take the place of the mines.

In Europe several mountain ranges have important mineral deposits, notably the Ural Mountains in the U.S.S.R., and mountains of southern Germany. The Erz Gebirge, or Ore Mountains, along the borders of Saxony and Czechoslovakia have contributed mineral wealth to this part of Europe for several centuries; but some of the ore deposits have been exhausted, and in others the mines have been flooded, thus putting an end to mining operations. This part of Europe, with its mineral resources of less importance than formerly, is marked by many small communities, now overpopulated since most of the people have lost their principal means of earning a livelihood.

Problems

1. Where is the hilly land nearest to your community, and for what purposes is it used?
2. What advantages for agriculture have level plains over sloping relief?
3. Compare the problems of a city built on hills with those of one located on a plain.
4. Why in general is there more erosion on mountains and hills than on plains?
5. Why is the snow line generally lower on the northern side of mountains in the northern hemisphere?
6. Why is the snow line lower in the Himalaya Mountains on the south than on the northern slopes?
7. Why are there more boulders in the beds of mountain streams than in those of the lowlands?
8. Why are mountain streams generally clear?
9. Account for the abundance of waterfalls in mountains.
10. Why are the snow line and timber line much higher on some mountains than others?
11. Why is intensive cultivation of mountain slopes carried on in southern Italy and almost none in southern California?
12. Name the outstanding mountain ranges and highest peaks in your state if such elevated areas exist.
13. List 10 of the world's most important mountain passes. What regions or nations do they connect? Name a city whose location is related to the traffic through each pass.
14. Find out from your instructor the approximate elevation above sea level for your city, and calculate the fraction of the earth's diameter that this represents.
15. What is the highest point in the world above sea level? The lowest point on dry land below sea level? What is the maximum difference in elevation on the earth's surface? What fraction of the earth's diameter does this figure represent?
16. Locate these mountain regions: Alaska Range, Cascades, Wasatch, Sierra Nevada, Colorado Rockies, Sierra Madre Occidental, Alps, Pyrenees, Himalayas, Caucasus, Carpathians, Atlas, southern Andes. In which of the above ranges do you find mining, pleasure resorts, sources of water power, lumber supply, sources of water, grazing, agriculture? Which of these ranges serve as refuges for oppressed people? For political boundaries? Which have the most advanced people culturally?

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CHAPTER 15: *The Oceans*

The ocean possesses great uniformity of conditions, compared with the diversity of environment that prevails on the land. It exerts much the same influence upon man all over the world wherever he comes in contact with the salty seas. Oceans cover three-fourths of the earth's surface, and land areas occupy only one-fourth; but, without the ocean as a source of rain, life on the land would be nearly impossible. Though water bodies separate the continents and islands, they also serve as convenient connections by providing an easy way for the transport of men, goods, and culture from one land to another. Oceans provide barriers to the spread of plants and animals and prevent their transfer to lands far distant from their original homes, yet they also transport some life forms by floating in favoring currents. According to the geologists, life appears to have developed first in the sea and later to have migrated from that environment to the land.

Oceans affect man in many ways, furnishing the vapor for most of the rain; tempering the climate of the lands; serving as carriers of commerce; and supplying food, some minerals, and raw materials. The sea has served as a route for the migration of man and has carried explorers and traders with new ideas and cultures to all the seacoasts of the earth. It has most profoundly affected the development and expansion of nations, the course of history, and the future of the earth's inhabitants.

The World Ocean. Land areas lack continuity on the earth, but the ocean completely encircles the globe and separates and surrounds the continents and islands. Parts of the ocean form enormous basins separated from each other by shallow water, broad straits, continents, and islands. The larger oceanic basins are the North and South Atlantic, and the comparatively small Arctic, along with the Pacific Basin. The so-called Antarctic Ocean is merely the waters south of the Pacific, Indian, and Atlantic oceans surrounding the continent of Antarctica; it does not occupy an oceanic depression. This southern ocean, however, forms the only continuous band of water encircling the earth without change of latitude. According to the usual separation of the world ocean, the five seas cover some 142,000,000 square miles, of which nearly half is included in the Pacific. Most of the rest of the waters are included in the Atlantic and Indian oceans. Some 10 million square miles of polar seas are of negligible importance to commerce. Another 10 million square miles consists of water that has spilled over onto the edges of the continents, covering the land to a depth of a few hundred feet. This gradually sloping platform, called the *continental shelf,* extends out until the ocean bed begins to deepen rapidly in its drop to the oceanic depths. The precise area assigned to oceans depends on the latitude limits decided upon and on whether rather isolated seas adjacent to the continents, like the Mediterranean, Red, and Bering seas, are included.

The ocean has a constantly changing but monotonous aspect on the surface, compared with the variety of relief features on land. Even the floor of the ocean is quite smooth in its minor irregularities compared with the land, since forces of erosion cannot carve the sea bottom as they carve the surface of an exposed land mass. Volcanic eruptions and folding of the rocks do make large inequalities on the ocean floor. Sometimes canyons and other erosion forms made on land later are submerged below the sea. Thus the Hudson River channel continues below sea level toward the edge of the continental shelf, and many oceanic canyons exist off the California coast.

Early Types of Boats and Ships. Any body of water, and especially the sea, exerts an attraction for man; and the construction of some form of boat came so early in the development of civilization that the date when the first ship was invented is entirely unknown. Primitive men all over the earth learned to construct canoes and other floating devices out of the best available materials. Boats have been built of dug-out logs, birchbark, hides stretched on framework, bits of board sewed together, bundles of reeds, inflated skins of animals, and other materials (Fig. 178). Today modern boats are commonly built of metal plates, riveted or welded together. Barges have even been made of such unlikely materials as reinforced concrete.

Some primitive men attained great skill in boat construction and built seaworthy craft in which they completed voyages of thousands of miles in length. Indians along the coast of North America from Puget Sound to Alaska built boats of great cedar logs hollowed out by fire and by chipping with stone implements. The center parts of the craft were steamed by the use of water and hot stones. When the wood became pliable from this treatment, the sides of the hollowed logs were wedged apart, and split cedar boards were used to build up the sides at the center. A high carved stern and bow were added to improve the seaworthiness and appearance of the boat. Such canoes were propelled by paddles, and in them Indians completed voyages of over a thousand miles (Fig. 101).

In the Pacific Ocean the Polynesians who inhabited islands from Hawaii to New Zealand attached outriggers to their canoes or fastened two canoes together to make craft propelled by sails of matting in which they traveled from Tahiti to Hawaii, 2,400 miles, and made other similar journeys. They commonly used a simple form of map to find their way. The Vikings of northern Europe a thousand years ago had boats large and safe enough to sail to Iceland and Greenland, where settlements were founded. From Greenland at least two trips were made to the mainland of America centuries before the first voyage of Columbus.

FIG. 178. Outrigger canoe, a relatively primitive type of water transportation, in heavy surf off the coast of Hawaii. The extinct volcano known as Diamond Head appears in the distance. (*Photograph used by permission of the Hawaii Visitors Bureau.*)

In the Mediterranean navigation developed at an early time, but sailors rarely tried voyages in winter when storms might be violent. Indeed many ships carrying goods between Egypt and Greece would creep along the coast from headland to headland, fearing to venture out of sight of land and take short routes directly across the sea. Oars, as well as sails hung from a single mast, were used for power, but galleys were preferred for war vessels because the ship would respond more quickly to oars than to the awkward sails then in use. Galleys were useless in the open Atlantic or during a storm in the Mediterranean, since in rough water banks of oars could not be pulled in unison. In storms seacoasts were very dangerous for sailing ships, since the boats lacked a keel and could not beat against the wind blowing onshore. Under such conditions, Mediterranean sailors hesitated to venture far into the Atlantic. Before voyages could be safely made across the ocean, the ships had to be planked over and a keel added, and erect masts were needed to which better sails could be attached. The invention of the compass helped navigators; but, without any compass and using only their knowledge of the stars, winds, and currents, neither the Norsemen nor the Polynesians hesitated to undertake long ocean voyages at a time when seamen in southern Europe were still terrified to sail beyond the sight of land.

Routes for Sailing Ships. Increased knowledge of navigation and improvements made on sailing ships made possible the voyages of discovery of Columbus, Vasco da Gama, Magellan, Cook, and other navigators. Merchants following the explorers soon learned the routes to follow in order to have the best chance for favorable winds to carry them to their destinations. Ships from Europe bound for India followed the northeast trades well westward toward Brazil, then beat southward across the equator, and continued south with the southeast trades abeam. The westerlies then were picked up, taking the boat around Africa into the Indian Ocean, where their arrival was timed to coincide with the summer monsoon, which would blow northeastward to India. The return was made after the northerly winter monsoon was established, and after reaching South Africa the southeast trades were used to the equator; but, because of difficulty in tacking against the northeast trades, the boats usually steered north into the mid-Atlantic to the westerlies, which blew them to the home port. By following favorable winds a ship traveled a longer distance but sailed to its destination more quickly than by attempting to beat against contrary winds. Sailing routes were thus largely determined by the winds.

Steamship Routes. After steam replaced sail, it became possible to follow the shortest distance between ports without regard to favorable or unfavorable winds. Sailing ships hardly ever use the Suez Canal on a voyage between Europe and the Orient because of the handicap of north winds and calms in the Red Sea and the expense of canal tolls and towage; but over 5,800 miles are saved between London and Bombay by steamers, which take this shorter route. Although the actual routes followed by ocean steamers depend primarily on the shortest path between terminals, other factors are also taken into consideration on voyages: currents, tides, winds, floating ice, fog, prevalence of storms, character of coast lines, distribution of population, available products for shipment, and other items.

Other things being equal, a steamship follows a great-circle route between ports (Fig. 8). The meaning of the expression will be clear if a string is stretched as short as possible, and avoiding land masses, across a globe between two ports like Seattle and Yokohama or New York and Liverpool. When directions followed on the globe are transferred to the Mercator map projection used by sailors, the course appears as a series of arcs or curved lines and not as a straight line. The actual shortest route between two points on the globe is always the arc of a great circle. By measuring on a globe it can be shown that the shortest distance from Chicago to Berlin

is across the polar regions. Perhaps this route will be used when aircraft are perfected for flying in the stratosphere above the earth's surface storms.

Factors Affecting Ocean Trade Routes. The ocean trade routes of the world today (Fig. 239) run in general between (1) nations in different stages of economic development; for example, England sends manufactures to Canada and receives foodstuffs; (2) parts of the world having different climates and hence different products; Europe and the United States buy rubber, palm oil, cane sugar, and spices from the tropics, which take flour, fish products, and machinery in exchange; (3) areas producing essential minerals lacking in industrial nations which must import them; thus the United States requires tin and formerly needed potash, while France, Germany, England, and Japan require petroleum.

Highway of Empire. To England, the route through the Mediterranean, Suez Canal, and Red Sea to the Orient is so important that it is called the "highway of empire." To guard this vital life line between the homeland and the rich markets and sources of material in India and the Far East, England has secured and fortified numerous fueling stations, supply ports, and naval bases, such as Gibraltar, Malta, Port Said, Suez, Aden, Colombo, and Singapore.

Seas and Cultural Development. Activities in nearly enclosed bodies of water like the Mediterranean Sea tend to develop along cultural lines similar to those which their bordering peoples enjoy. Thus the Cretans, Phoenicians, Greeks, and Romans successively dominated the commerce and cultural development of the Mediterranean shores. Later, during the Middle Ages, Venice and other Italian trading cities chiefly controlled the business of the area.

In the Baltic Sea during the Middle Ages the trading towns of the Hanseatic League dominated affairs, and the Teutonic culture spread eastward until it encircled the big embayment. The Slavs, Finns, and other eastern Baltic peoples accepted the Western European religion rather than the Greek Orthodox Church, as well as other Western attitudes.

Expansion and spread of culture similar to the examples given have occurred in other nearly enclosed seas. Centuries ago the Arabs and their culture spread along both shores of the Red Sea and even down the coast of East Africa. In recent years, Italy for a time came into control of the Adriatic Sea, as did Japan in the Yellow Sea and the Sea of Japan. The United States dominates trade in the Gulf of Mexico and the Caribbean, often called the "American Mediterranean," and to a considerable extent (at least during wartime) it exercises strategic control over the area.

Oceanography. The term oceanography is applied to the study of the oceans, their waters, and their floors. The ocean, already covering so much of the earth's surface, contains enough water to cover the entire surface of the earth to a depth of about 2 miles; but land is exposed on about one-fourth of the surface, and the actual depth of the ocean therefore averages about 2½ miles. The most profound depths occur in elongated troughs called deeps, which are generally parallel to and not far distant from recently uplifted mountainous coasts or islands. Apparently the uplift of the land and depression of the sea bottom occurred simultaneously, and possibly the one compensated for the other. The deeps in the Pacific lie off Japan, south of the Aleutian Islands, east of the Philippines, east of Guam, and near the Tonga Islands. Depths exceeding 6 miles have been recorded east of the Philippines and off the island of Guam. In the Atlantic the greatest depth is about 5 miles, located in a deep trough north of Puerto Rico. The centers of ocean basins are never so deep as the troughs lying comparatively near the shores.

Deposits in the Sea. Sediment brought by rivers and other agents from the continents is usually deposited near the shore in the shallow waters of the continental shelf on the edge of the continents. The material is well sorted by the water, with coarse debris being

dropped near shore and successively finer sediment being carried outward toward deeper water. The continental shelves, especially the shallow areas called "banks," are favored places for multitudes of fish. The commercially important deep-sea fisheries are principally based on the fish caught on the banks of Newfoundland, the North Sea, the Sea of Japan, and the Gulf of Alaska. The ocean bottom in deep water receives little but oozes composed mainly of the remains of marine animals and plants.

Chemicals. Ocean water contains some of practically every chemical and element found on the land; even millions of pounds of gold are said to exist in sea water in a very finely divided state. Common salt is the most abundant dissolved substance, over 14 million billion tons of it existing in solution. This is sufficient salt to make a layer 400 feet thick over the earth. Much lime carbonate is brought into the sea by rivers, but it is steadily absorbed to make the shells and skeletons of sea life, so that the percentage of the substance in the oceans is much smaller than that of salt. Ocean water always contains some air, the coldest water usually containing the most, since solubility of gases decreases with increase of temperature. This dissolved air provides the oxygen for all sea life except some large mammals like whales and seals.

Pressure. Sea water has a slightly greater density than fresh water because of its mineral content. One cubic foot of sea water weighs about 64 pounds, compared with 62½ pounds for fresh water. Pressures in the depths of the ocean become enormous. The pressure at a depth of 1 mile exceeds 1 ton per square inch, and at the greatest depth in the ocean the pressure is nearly 6 tons for every square inch. These great pressures do not affect sea life, since the external pressure is balanced by the internal pressure of organisms. However, if a deep-sea fish is brought rapidly to the surface, it is distorted by expansion against the reduced pressure. Any body, not perfectly solid, lowered to the depths of the ocean, would be compressed into the smallest possible space. Inasmuch as water is practically incompressible, the density of water on the bottom of the ocean is little more than that at the surface. Any object that is heavier than water at the surface will sink to the bottom of the sea.

Temperature. The surface temperature of ocean water varies with the latitude, being about 80°F. near the equator. At 40° latitude it has an average temperature of nearly 60°F., and it is near freezing in polar regions. Since water increases in density with decrease in temperature, the water on the bottom of the sea is near the temperature of greatest density for salt water and averages from 30 to 40°F. from polar to equatorial regions. Vertical movements of the ocean water result from differences in temperature, cold water sinking and forcing the lighter warm water to rise. If a nearly enclosed sea has a shallow entrance like those of the Mediterranean or the Red Sea, no cold water can enter below the temperature at the depth of the entrance. Temperatures on the bottoms of these seas are therefore the same as those at the bottoms of the shallow straits of Gibraltar or Bab el Mandeb.

Ocean Currents. Although the absolute cause of ocean currents has not been definitely agreed upon, they probably result from the movements of water caused by the drag exerted by the prevailing winds, combined with the effects of the earth's rotation and the position of land masses, which deflect them. Vertical movements of the ocean water may result from temperature changes, evaporation, and the influx of fresh water from rivers and other sources. The lateral movements of sea water, which make up the greatest oceanic currents, seem to be the result of the trade winds and prevailing westerlies (Fig. 179).

Both the northeast and southeast trades cause ocean currents and by their steady movements set up a slow drift of water toward the equator, flowing at a rate of perhaps 25 miles a day. The rotation of the earth causes both winds and ocean currents to be deflected to the right in the Northern Hemisphere and

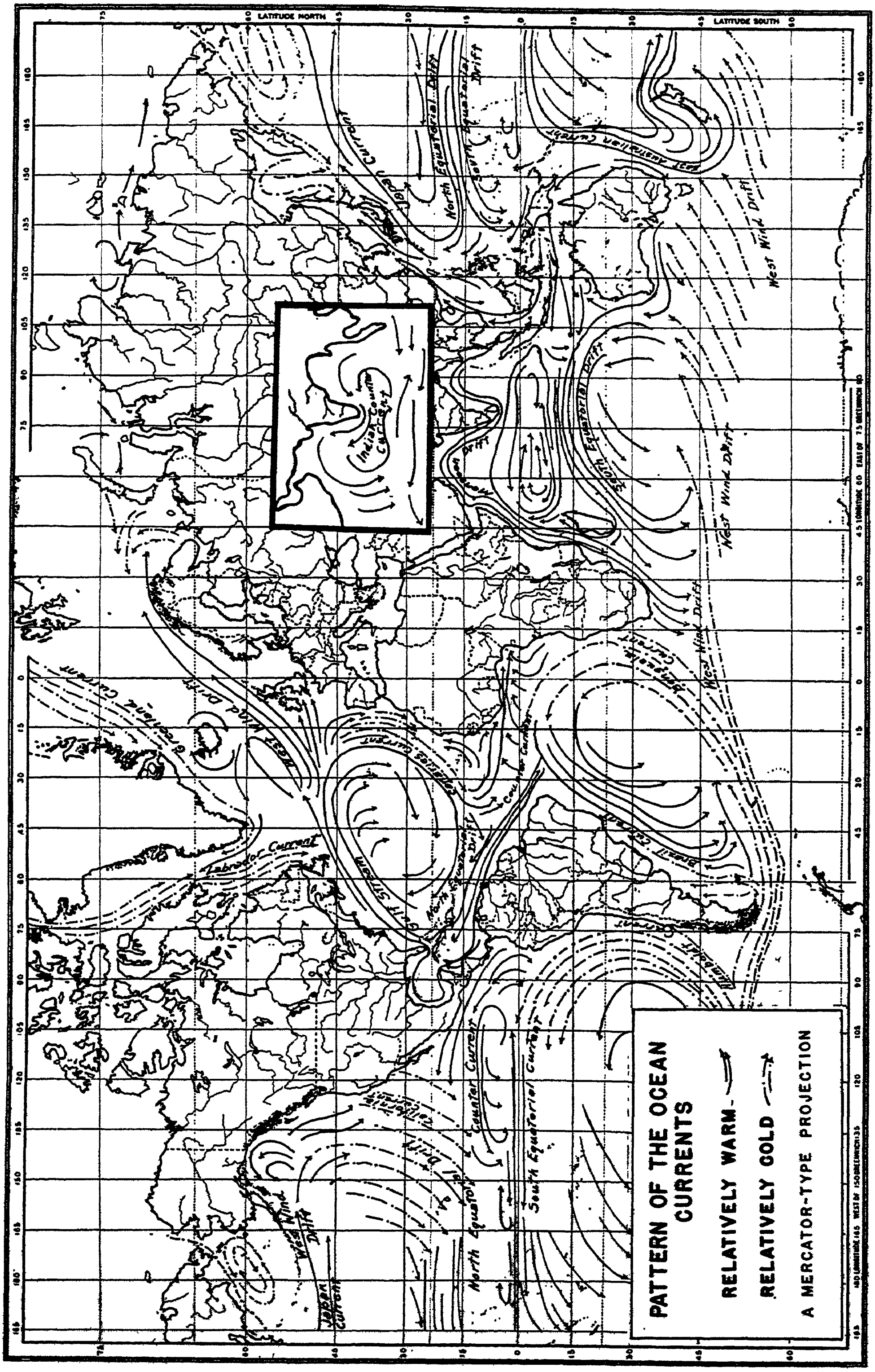

FIG. 179. Pattern of the ocean currents. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

to the left in the Southern Hemisphere. As the equator is approached, the wind is blowing nearly from the east, and the currents drift westward until they reach a continental land mass. Then the equatorial drift is deflected away from the equator by the position of the continent and by the rotation of the earth; it then moves north or south into the prevailing westerlies, which blow the waters eastward until another continental mass is reached. There the earth's rotation, deflecting objects to the right or to the left, combines with the outline of the continent to deflect the currents southward back to the trade winds, which provide renewed energy to keep up the oceanic drift. In the Northern Hemisphere the North Atlantic and North Pacific drifts move in a clockwise direction, while in the Southern Hemisphere the motion of the South Atlantic, South Pacific, and South Indian ocean drifts is counterclockwise.

In both hemispheres the water moves from east to west in the trade winds and from west to east in the prevailing westerlies. These ocean drifts are gigantic eddies in the ocean, thousands of miles in extent, around which water is moved with a velocity of perhaps 10 to 25 miles per day. Sometimes special names are applied to parts of these drifts. The Japan Current in the northern Pacific, for example, is merely the northern and western portion of the North Pacific drift. This part of the drift is warm because the water comes from equatorial regions, where it was warmed as it flowed for a distance of nearly a thousand miles beneath the tropical sun. A floating object might take from 1 to 2 years to complete the circuit of the North Pacific drift. In the North Atlantic drift, a comparatively calm area that occurs near the center of the big eddy is called the Sargasso Sea and was described by Columbus and other explorers. Seaweed and other floating objects are somewhat more abundant in the Sargasso Sea than in the ocean currents, but most of the popular tales concerning this "sea" have little basis in fact.

Cold Currents. Where winds blow offshore, the surface water, which is warmer than that in the depths, is blown away, allowing colder water to well up in its place. The cold temperature of continents along leeward coasts comes partly from this welling up of cold water from below, and only in part from an actual movement of cold surface water from polar regions. Thus in the latitudes of the trade winds we have cold currents on the west coasts of continents, as the California Current off that state, the Canaries Current off northwestern Africa, the Benguela Current off southwest Africa, and the Humboldt, or Peru, Current off the southwest coast of South America.

The Peru Current. The Peru Current is probably the world's most important cold current. Between Antarctica and the southern extremities of Africa and South America, the southern ocean completely encircles the earth. This is the realm of the "roaring forties" in the prevailing westerly winds (Fig. 36), which set up an eastward-moving current called the *west wind drift.* When this impinges on the continent of South America, part of the cold southern waters is deflected northward and moves along the west coast of South America as the Humboldt, or Peru, Current (both names are in use). From middle Chile almost to the equator, the trade winds blow strongly offshore and, by blowing away the surface waters, allow cold water to rise from the depths. Hence the low temperature of this region, considering its latitude, results from both the upwelling of cold water and the movement of the polar waters toward the north. This current extends north as far as the equator, bathing the shores of the Galápagos Islands, which lie exactly on the "line," and keeping the temperatures of those islands more moderate than tropical.

Since the solubility of a gas in water varies inversely as the temperature, cold water contains more oxygen than warm water, which favors the development of abundant floating sea life called plankton in the Peru Current. The growth of plankton is also favored by

abundance of nitrates and phosphates in the cold upwelling water. Myriads of crustaceans and other small sea life feed on the plankton, and vast schools of fish in turn feed on the smaller sea life. Attracted by the abundant fish and other food, sea birds and sea lions abound along the western shores of South America. Many of the birds nest on small desert islands off the coast of Peru, where through the centuries their refuse has accumulated to depths of more than a hundred feet, forming by means of slow decay a material called *guano*. This guano contains a high percentage of phosphates and nitrates and is a very valuable fertilizer. During a half century, Peru sold $375,000,000 worth of guano to the markets of the world. The birds are now well protected in their nesting places, and guano beds are worked only at intervals of several years, with precautions being taken to protect the wealth-producing wildlife, which probably is the most valuable type of bird life in the world.

The Benguela Current. The Benguela Current off southwestern Africa closely resembles the Peru Current. Both are cold currents, both are south of the equator and flow northward to within a few degrees of the line, and both are located off a desert coast. In both currents are found islands to which birds resort and deposit guano, though the African deposits were not well protected and are no longer highly productive. The influence of these currents in lowering coastal temperatures is similar; the port of Swakopmund in Southwest Africa has an average temperature ranging from 55°F. in September to 63°F. in March and is reported as having the lowest average temperature for its latitude in the world (Fig. 180).

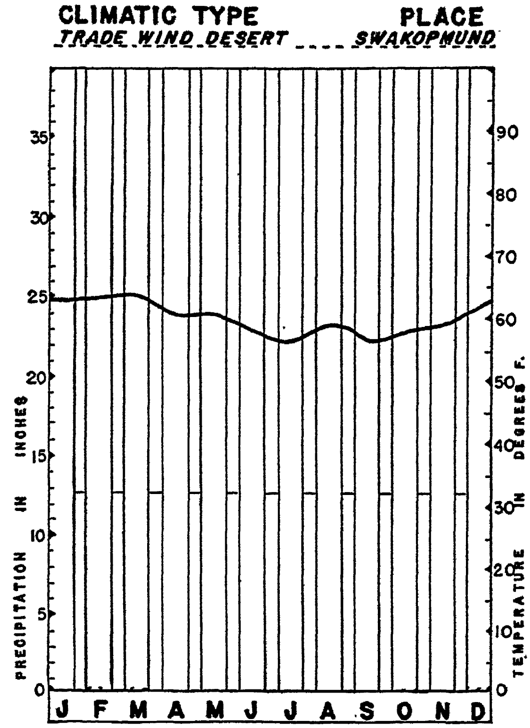

FIG. 180. Climatic graph for Swakopmund, Southwest Africa. A low-latitude trade-wind desert station where temperatures are modified by the presence of a cool ocean current offshore.

Cold Currents in the Westerlies. In the prevailing westerlies, cold currents hug the eastern coasts of the continents partly because the rotation of the earth deflects anything moving toward the equator to the west. The best known of these cold currents is the southward-flowing Labrador Current off northeastern North America, and the Kamchatka Current off Siberia. A similar stream, the Falkland Current, is found on the eastern coast of South America off Argentina, but Africa does not extend far enough south to have such a current. Some of the cold water in the Labrador and other currents may be derived from the depths when the prevailing westerlies blow the surface waters away. The Labrador Current, by bringing floating icebergs south from the glaciers of Greenland, endangers the shipping lanes from America to western Europe. The danger from icebergs is increased by the prevalence of fogs near the contact of the cold Labrador Current and the warm Gulf Stream. In both the Labrador Current and the Kamchatka Current abundant plankton and associated food are available for fish. Some of the most important fishing grounds in the world are along the banks of Newfoundland and near Japan and the Siberian coast (Fig. 247).

The Gulf Stream. The Gulf Stream is the most famous and important warm current on earth. A curious fact that concerns this current extending across the North Atlantic is that much of the water of the Gulf Stream actually comes from the South Atlantic Ocean. The southeast trades cause a drift of water toward equatorial South America, and this drift is divided by the angle of South America made by Cape São Roque, part of the water being deflected northward across the equator into the Caribbean Sea. From here it flows into the Gulf of Mexico and finally out through the Straits of Florida into the Atlantic Ocean. The narrow channel between Cuba and Florida acts like the nozzle of a hose and forces the water to flow swiftly through it with a velocity as high as 4 or 5 miles per hour.

On leaving the Straits of Florida, the Gulf Stream is several hundred feet deep and about one hundred miles wide. Flowing northeasterly toward Europe, it spreads out and finally divides, one portion turning east to join the North Atlantic drift off Europe. Another part continues northward along the coast of Norway to the Kola Peninsula and Murmansk coast of the Soviet Union, keeping those coasts ice-free even within the Arctic Circle. Still another branch wanders off toward Iceland and disappears in the arctic seas. The warm Gulf Stream naturally modifies the temperature of northwestern Europe in the wintertime, although the land there would have a mild oceanic climate anyway, since it lies on a windward coast in the prevailing westerlies. Nevertheless the Gulf Stream raises the average winter temperature in western Europe at least a few degrees. Off the United States the edge of the Gulf Stream is well defined by a "cold wall," and water temperatures may change by 10° within a mile or two.

Warm Currents in the Oceanic Drifts. Warm currents exist where the direction of the drifting water comes from the tropics into naturally colder regions. The warm current loses heat from the water as it moves into colder climates; but, because it is warmer by contrast than the ordinary surface temperatures for the poleward latitudes, it will be called a warm current. The Japan Current and Brazil Current are examples, and the former is really the northern part of the North Pacific drift. Conversely, a cold current in the tropics may be warmer than a warm current toward the polar seas.

Cause of Tides. The tides can be entirely explained only with the aid of higher mathematics; but if only the effects of the moon's attraction are considered, the most important factor in causing tides can be made clear. The side of the earth toward the moon is nearer that body than the rest of the earth. The moon's gravitational pull being greater than for the rest of the earth, water therefore tends to move toward the moon. On the opposite

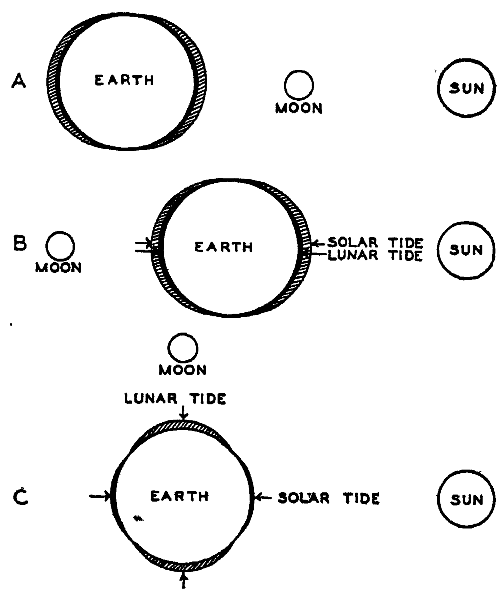

FIG. 181. The tides. When the moon and sun are aligned on the same side of the earth, as in *A*, or when they are on opposite sides of the earth, as in *B*, they cause spring tides. Tidal conditions shown in *B* follow those of *A* by about two weeks. The moon is nearer the earth than the sun; hence its tidal effect is about double that of the sun despite their disparity in size. Conditions that prevail when low, or neap, tides occur are shown in *C*, when the sun and moon affect the earth from different directions. About two weeks after the position shown in *C*, the moon will be on the opposite side of the earth, and neap tides will be repeated.

side of the earth, the effect of the gravitational pull of the moon is less than at any other portion because of the greater distance to the moon; hence a tendency exists to pull the earth away from the water, producing another "bulge," or tide wave (Fig. 181).

In reality high tides rarely coincide with the greatest altitude of the moon. This results in part from the configuration of the coasts, but also from the fact that tides move from the horizontal pull of the moon and that the sideways pull is zero when that body is overhead. That is, tidal movement, or the ebb and flow of tides, result from the horizontal rather than the vertical component of the moon's gravitational force of attraction.

Tide Periods. Since tides result mainly from the attraction of the moon, the periods between high tides are controlled by the revolution of our satellite. During half the time from moonrise to moonset, 12 hours and 25 minutes, there is a tidal surge in one direction until the moon passes the vertical and the horizontal force ceases; then the surge begins in the opposite direction. Thus along a coast for 6 hours and 12 minutes the tide flows, and then for an equal length of time it ebbs.

On a globe covered entirely with water, the two waves would follow the movements of the moon. Modification of the tides results from the continents and islands, which cause deflection of the tides and may also change the time of high and low tides so that the flow and ebb do not correspond with the theoretical periods. Tides require a large body of water in which to develop. Even the Great Lakes are too small for the tidal range to exceed 2 inches. The moon rises about 50 minutes later each day; hence, in theory, high tides are separated by 12 hours and 25 minutes in time. This time interval holds approximately for the Atlantic Ocean; but, in some parts of the world like the North Pacific coasts, the flood tide meets the ebb tide in such a way that they cancel each other; at other places the two crests coincide to make one high tide and the two troughs join, making one low tide each day. All kinds of mixed tides and gradations occur between the two extreme types of twice each day and once each day. Some localities like Tahiti have practically no tides.

Spring and Neap Tides. The sun modifies the effect of the moon on tides. The two bodies act together during new or full moon to cause spring tides of greatest range. During the first and third lunar quarters, however, they act at right angles to each other, the sun neutralizing part of the effect of the moon, and neap tides result, with a minimum range from high to low tide. Though the sun has the mass of 26,000,000 moons and gravity depends directly on the masses involved, the moon has over twice the effect of the sun in producing tides because the moon is only about $\frac{1}{380}$ as far from the earth as the sun is.

Effects of Tides. When tides enter a long shallow estuary that narrows inland, the water piles up higher toward the head of the bay, thus causing a great range between high and low tide. This takes place at the Bay of Fundy, with an extreme tidal range of 50 feet, and at Cook Inlet, Alaska, which experiences a tidal range of 40 feet. When tides enter a bottle-shaped bay, like those at San Francisco or Liverpool, the water spreads out, and the height of the tide is reduced from that on the coast outside the bay. The availability of inlets for navigation obviously is affected by the height, character, and time of the tides. Tides increase the depth of water in shallow harbors and over the shallow entrances of some harbors, thus making ports available during high tide; they scour out the entrances of inlets, remove wastes dumped into the sea from cities, distribute the mud and silt brought to the ocean by rivers, modify the contour of shore lines, and affect the human use of coasts in many other ways. Thus far little practical use has been made of tidal power, although development of hydroelectricity would be possible at certain places of large tidal range, like Passamaquoddy Bay in northeastern Maine.

Problems

1. How do tides help keep harbors clear of refuse?
2. How do tides make it easier for shipping to use harbors?
3. By whom are tide tables regularly used?
4. Name some seafoods that are available in local markets, and investigate their probable domestic and foreign sources.
5. Distinguish among shellfishing, onshore fishing, and deep-sea fishing.
6. Why do ocean trade routes often converge at the mouths of large rivers?
7. Since a great-circle route is the shortest distance between terminal points, why do some shipping routes diverge from this preferred course?
8. Why is ocean water salty?
9. What part of the world is most affected by the Gulf Stream? How?
10. What part of the world is most affected by the Japan Current?
11. Why are the cold Labrador and Kamchatka currents on the eastern sides of continents while the Peru Current, also cold, is on the western side of South America?
12. What determines whether a current is called "warm" or "cold"?
13. Make a careful study of the ocean currents of the world (Fig. 179); then locate those parts of the earth whose temperatures are noticeably affected by the currents, as shown on the map of world isothermal conditions (Fig. 22).

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CHAPTER 16: *Coast Lines and Islands*

Coasts are zones of transition from land to sea, and they partake of the characteristics of both environments. Along coasts, the inhabitants are simultaneously attracted and repelled by the sea. Natives in need of food are attracted because they can obtain it from fish, shellfish, and other sources that provide a more certain and abundant food supply than that which is afforded inland, especially if the land is mountainous or heavily forested. Lacking seaworthy craft, men were at first frightened by the rough open sea; but, after they gained confidence by learning seamanship in the calm waters of protected bays and harbors and by finding how to build safer boats, they ventured farther into the ocean and finally developed into fearless seafaring people.

Coast Lines

Contrasting Shore Lines. The coast lines of oceans are of contrasting types. Where land has risen or emerged relative to the sea, coast lines are regular and there are few harbors. Where the land has sunk or submerged relative to the sea, coasts are "drowned" and are very irregular in form (Fig. 158). Emergent shores are often smooth and regular, since the sea bottom, which has become land, is generally smooth because it is unaffected by erosion of running water and other agencies that normally carve the exposed land surfaces. Rising coasts may be high and steep where uplift of the land has been rapid, but they are low and generally sandy where the uplift was slow and of less degree. The latter type of coast provides excellent bathing beaches but no good harbors. Regular coast lines have enjoyed great development as summer resorts during the last half century. Atlantic City, Deauville, and Biarritz are examples of popular seaside resorts. Expansion of highways and increased use of the automobile largely account for the growth of beach resorts.

Emergent or Regular Coasts. Along regular coasts that lack adequate harbors, goods must be landed in rowboats or lighters from ships anchored offshore. These landing places are called *roadsteads* and are dangerous for ships in storms because they offer no protection from winds and waves. Examples exist on the coasts of northern Chile and Peru, the eastern coasts of Madagascar, the coast of Patagonia, and at the anchorage at Nome, Alaska. Generally the landing selected has access to the interior by some valley or pass that determines the natural trade route. Where wave action is strong, material may have been washed away and cliffs developed that make landings even more difficult. The regular coast line of western Africa affords very few natural harbors, and ships merely utilize roadsteads where landings are made at the most accessible routes inland. Roadstead anchorages are less dangerous in the calm waters of the tropics than along coasts that experience the prolonged storms of the prevailing westerlies. Some of the great harbors of the world were originally roadsteads; among them was the anchorage at what is now Los Angeles harbor. Constant dredging and the addition of breakwaters and piers made an artificial harbor (Fig. 182) that completely altered the original character of the roadstead.

Drowned or Submerged Coasts. When land sinks below sea level, the valleys become sounds, straits, or inlets. Isolated hills become islands, and ridges form peninsulas. A "drowned" coast has an abundance of harbors. The coasts of New England, Chesapeake Bay, and Puget Sound, and most coasts

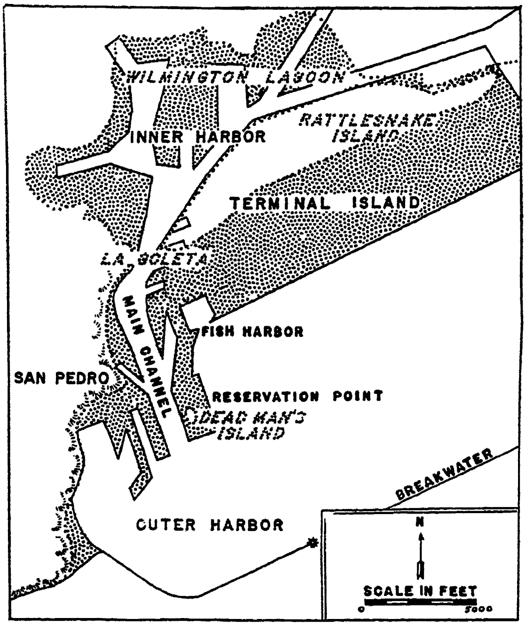

FIG. 182. Los Angeles harbor in 1868 (dotted lines and names) and in 1946 (solid lines and names). Note the extensive changes brought about by human activity. Filled land, largely from dredged material, is indicated by stippling.

in western Europe represent examples of submerged coasts. Their protected waters provide superior places for learning the handling of boats, and irregular coasts are therefore generally the homes of fishermen and sailors. This may be the more true since the "drowning" of the land probably covered the fertile plains and lowlands most suitable for agriculture and may have left so little tillable land that the opportunity for farming is well nigh destroyed in such regions.

Mountainous coasts that have been strongly glaciated may have many *fiords*. These are coastal valleys that appear to have been overdeepened by ice erosion below sea level and then invaded by the ocean water when the glacier melted. Some fiords penetrate many miles into the mountains (Fig. 145). Fiord coasts are found in Norway, Alaska, southwestern New Zealand, and southern Chile. The cliff walls of the fiords are generally bare rock with very little soil and so steep that cultivation is impossible and even forest growth is difficult. Only the fans and deltas formed by torrential streams supply limited amounts of land for cultivation. Farming on Norway's coast and in southeastern Alaska is greatly handicapped by this lack of any considerable area of farm land. Fishing villages in fiords are often built near the head rather than the mouth of the fiords so that their inhabitants can secure more level land on which to build and can have a chance to supplement fishing by gardening and dairying.

Where mountain ridges descend into the ocean at nearly right angles to the coast line, a *ria* coast develops. These inlets somewhat resemble fiords, but they are unglaciated. The word ria comes from this type of coast in northwestern Spain at El Ferrol, Vigo, and other ports. The eastern side of the Adriatic Sea has a similar coast. Rias usually form splendid protected harbors, but access inland may be so difficult over the mountains that fine harbors support only insignificant villages.

Work of the Waves. Coast lines are subject to constant attack by waves, which materially modify them. Along irregular coasts, exposed headlands and other points will be attacked and eroded by the waves, and the resulting debris is deposited to the leeward of the coastal projections, frequently as bars across the calm waters of adjacent bays (Fig. 153). The net effect of this erosion and deposition is to make an irregular coast more regular by cutting back the projecting parts and depositing barrier beaches. In the course of time this feature may be filled with silt and plant remains, forming first a tidal marsh and then solid ground.

A regular coast attacked by the waves tends to be cut back most rapidly in places where the rocks are weaker and the coast less rugged, or where the currents and waves can work most effectively. After a time, such a coast has many little coves and isolated offshore rocks called stacks, which are developed by erosion of the waves. Under certain circumstances, coasts may be eroded several feet

during a single year. Some towns that were several miles inland during the Middle Ages are now situated along the coast of Great Britain. One section on the outside of Cape Cod is now being eroded at the rate of about 5 feet a year. Charts of coastal waters must be revised every few years because of the shift of the coast lines and the development of new bars that are formed by wave erosion and deposition.

Harbors and Seaports

Harbors and ports are both on coasts, but they have distinct meanings. *Harbors* are places of shelter for ships. *Seaports* are the sites used by ships. Ports, where feasible, utilize harbors, and the largest seaport cities are generally located on good harbors. If there are products to ship and no harbor is available, however, a port may be located in places with very little protection. A roadstead has no harbor. Ships remain offshore, and goods move to and from the landing or port by lighters or other small boats. At the poorest of locations goods or passengers may have to be landed through the surf onto the beach, no wharf being built. If little or no freight is available for shipment, even fine landlocked harbors cannot support a seaport town. The usefulness of harbors is in direct proportion to the productiveness of their hinterlands.

Sometimes the words *haven* and *anchorage* are substituted for harbor. Many place names include the words harbor or haven. Le Havre, France, is an example, as are also Grand Haven, South Haven, and Indiana Harbor on Lake Michigan.

Origin of Harbors. Harbors may be formed in many different ways. Besides the harbors of "drowned" coasts, the fiords and rias aforementioned, harbors may result from deposition. Sand bars, when built above sea level by wave and wind work, may partly enclose a lagoon, which will form a harbor. The cities of Erie on Lake Erie, Duluth on Lake Superior, Port Angeles in Washington, and San Diego in California occupy this type of harbor site. Spits, hooks, and barrier beaches have formed other harbors like Provincetown, Galveston, Miami, and Durban. Coral reefs may form the protecting barrier, as in the harbor of Honolulu, Hawaii; Suva, Fiji; and certain coral atolls in the South Pacific. Lava flows and glacial moraines have at times formed barriers that protect harbors. Sometimes volcanic craters form deep landlocked harbors when one side is breached by wave erosion, as at Pago Pago in Samoa, or when the land has sunk flooding the crater, as at Aden and Christchurch. Sometimes a block of the earth's crust sinks below sea level. Some of the best harbors have been formed in this manner, including San Francisco and Rio de Janeiro. Offshore islands may protect a harbor from excessive wave action, as at Boston, Juneau, Boothbay, and Los Angeles. River mouths are preferred as harbors because they afford easy access to the interior unless the river has sand bars or a delta that may interfere with navigation. Most of the German ports, the ports of Great Britain, and many ports of the United States are on the rivers near their mouths.

Importance of the Hinterland. A good harbor alone is not sufficient for the development of a great seaport. In order for a harbor to be extensively used, it must be needed for the export or import of goods. Magnificent harbors in Alaska, in Labrador, and in southern Chile are little used because their hinterlands are undeveloped or lacking in resources or are not readily accessible from the sea because of coastal mountain ranges. On the other hand, coasts without any good harbors will be provided with seaports if important quantities of goods are to be shipped out. Under these conditions, man will build breakwaters or dredge shallow bays and create harbors like those at Los Angeles and Galveston. Even the great port of Buenos Aires is largely artificial. If no harbor whatever exists, goods may be carried to and from the shore in small boats. As before mentioned,

the term roadstead is applied to these landing places where ships must lie offshore and land passengers and cargo by lighter or barge. If a great city is to develop as a seaport, the character of its hinterland is of more importance than the quality of its harbor, for it is possible to change the physical character of the harbor, but it is almost impossible to make major changes in the type of products that the hinterland provides for export. The largest cities in existence, New York and London, have excellent river harbors at the heads of wide bays, combined with first-class communication with rich and extensive hinterlands.

Desirable Characteristics of a Harbor. An ideal harbor would be of good size, thoroughly protected from storms, with deep water close to shore and a firm sandy bottom for anchorage of ships, and lacking troublesome silting problems. It should be free from dangerous reefs and shallows and without fog, ice, strong winds, or dangerous currents or shifting sand bars. There should be little tidal range, although entrance to shallow harbors may be facilitated at high tide by a range of 6 or 8 feet between tidal extremes. At the same time, there should be sufficient tidal scour to prevent stagnation of the waters of the harbor. The entrance channel should be large, fairly straight, and deep enough to make the approach both easy and safe. Suitable building sites should be available for the seaport city, and there should be routes tapping the hinterland. Few harbors, of course, approach this ideal combination of natural factors.

The Ideal Port. The ideal ocean port, in addition to a superior harbor with as many of the favorable features named above as possible, should have adequate facilities for handling freight and passengers, a location on the principal world trade routes, and an easily accessible hinterland that both produces and consumes goods.

Aids to Navigation. To aid navigation, governments have carefully surveyed and published charts of coasts and coastal waters, built lighthouses, and installed buoys and lights to make channels. They also maintain fog warnings, issue weather forecasts, print tide tables, and provide other navigation aids and lifesaving stations in case of disaster.

New York. Among ocean ports, New York has ranked first in value of trade among the ports of the world for many years. Reasons for its importance are partly natural and partly human. The harbor has a long frontage with deep water close to shore, and it lies convenient to the relatively short North Atlantic route to Europe. It was built at the mouth of an easy route inland via the Hudson River (Fig. 252) and the Mohawk and Genesee valleys to the Great Lakes and Mississippi Valley, and it has a small tidal range and little fog or ice. It is generally free of currents, shoals, and other obstructions. New York handles between 40 and 50 per cent of all foreign trade of the United States. Twelve lines of railroads reach the harbor, although only three terminals are situated on Manhattan Island itself. To handle the enormous transfers of freight, great numbers of piers, wharves, and warehouses, tugboats, lighters, and floating elevators have been built and equipped with modern machinery. Both private enterprise, as at Bush Terminal, and the municipality, as at Staten Island, have constructed special piers and warehouses for use by shipping firms. Furthermore New York is a great manufacturing center with nearly a million employees and a large consuming market itself in the 10 million inhabitants of the city and vicinity.

Changes in Usefulness of Ports. When modern trade routes differ from those of the past, a port may decline. Thus Venice, once the greatest trading city, now has small importance as a port and has declined to little more than a tourist attraction. Bruges, great port and industrial town in the Middle Ages, is of small significance today, partly because large boats cannot use the silted shallow channel that leads to the port. Bristol and Plymouth in colonial days were leading English ports; but, with the development of the in-

dustrial revolution, new ports like Liverpool, Newcastle, and Hull expanded to serve the iron, coal, and textile regions in central England. The old ports in Cornwall, with few industries, declined.

Modern dredging machinery changes inland cities into seaports by constructing ship canals like those from Liverpool to Manchester and from Galveston Bay to Houston. By the building of breakwaters and by dredging and other improvements, poor natural harbors have been made into safe convenient modern ports where a natural haven was lacking and a rich hinterland needed an outlet. A few of many possible examples include Cherbourg, Callao, and Dakar.

In modern times increased draft of ocean vessels has compelled the building of outports downstream from the old seaport established at the former head of ocean navigation up the rivers. Thus Bremen has its Bremerhaven and Hamburg its Cuxhaven.

The building of the Suez and Panama canals shortened some ocean trade routes and changed the relative importance of certain seaports. Magallanes (Punta Arenas) and Port Stanley in the Falkland Islands declined when many ships abandoned the route around South America in favor of the Panama Canal. St. Helena, Capetown, and Mauritius declined after the building of the Suez. On the other hand, Aden, Port Said, Bombay, Los Angeles, and Panama increased their commerce upon completion of the canals.

Human Relationships to Coasts

Human Activities in Seaports. Seaports receive goods and ideas from the whole earth. A seaport has an advantage as a manufacturing center, since raw materials can be received by both sea and land. They are manufactured and then shipped abroad by boat and inland by rail or truck. London, New York, Barcelona, and Marseille are great world ports and also important industrial centers. Because of intercourse between ships and world-wide ports, coastal cities usually are made up of a great variety of racial and political types. On the whole, seaports have reputations as liberal or radical centers of thought and action. Ports also cater to the tourist and casual sailors, and commonly a section of the city specializes on their entertainment. Interracial marriage is more common in coastal transition zones than in inland cities.

Characteristics of Coastal Peoples. The coast lands represent a zone of transition that is intermediate between land and sea. Coastal cities serve as middlemen between foreign lands and inland centers for the exchange of commodities. Coast regions have easily recognizable characteristics. The term "tidewater" to a Virginian suggests a definite zone of peninsulas and estuaries, swamps and old plantations, as well as the modern Norfolk navy yard; half-forgotten wharves and old tobacco warehouses, duck shooting, oysters, and terrapin. A similar coastal area, the Campania in Italy, has been difficult to reclaim as agricultural land. In Germany the seaports are built on rivers from 10 to 60 miles upstream from the sea, where a firm site exists for buildings. The coastal zone itself is often sandy or swampy and is thinly populated. New Orleans is built more than a hundred miles from the Gulf, on the first practicable land for a city, but all heavy buildings must be placed on piling driven into the mud.

Coasts with Poor Hinterlands. If coasts are isolated or unhealthy, lacking ports for trade or otherwise difficult of access, the inhabitants may be backward and little affected by the sea. The Gulf of Guinea coast, Mosquito coast of Central America, and the whole of northern Australia are examples.

The Baltic states are wooded, swampy, cold countries with poor soils and few resources except timber. These coastal areas, to the Slavs, were less attractive for farming than more fertile areas inland, and they were left for a time to weaker peoples like the Finns, Letts, Estonians, and Lithuanians. Later, how-

ever, when Russia felt the need for better outlets to the Baltic Sea, political control over much of the coastal area was secured. When attached to a populous country like Russia, the use of ports like Riga on the Baltic can be expected to increase.

New England. When the population of a coastal land has increased beyond its capacity for support, the people of necessity must turn to manufacturing or the sea. Farming in New England was of a subsistence type, and even in colonial times some residents turned to fishing, home manufactures, and trade for a living. Excellent harbors, abundant timber for shipping, and available goods for export—cured fish, lumber, and small manufactures—stimulated the development of shipping. In the early years of the republic, the clipper ships, fastest sailing vessels known, were invented and perfected in New England, and the American flag was seen in every foreign port. The invention of steam and the iron-hulled boat was advantageous to England, with its important iron industry, and helped bring a decline in New England trading ships, which were made of wood and used sail. New Englanders also entered the whaling industry and until the Civil War led the world in catching whales. Whaling declined when the discovery of petroleum injured the price of whale oil and the opening of the West offered other opportunities for investment (Fig. 183).

Norway. At present the Norwegians, only 2 per cent of whose land is tilled and who therefore turned to the sea for their living, dominate whaling, catching the creatures mainly in the antarctic seas (Fig. 184). Whale oil now is used for soap and margarine while the remainder of the carcass is ground into fertilizer. Much of the world's carrying trade is carried by Norwegian vessels, many of which rarely visit their home ports. The Norwegians are leaders, too, in fishing in the waters of northwestern Europe. Some of the fish are used for food in Norway, but large quantities

FIG. 183. Portsmouth, New Hampshire, former center of much of New England's shipping activity, has become an attraction for tourists who appreciate its old shipowners' dwellings. The beached dory is typical of small fishing craft along the coast.

are exported, especially to Spain and other countries of southern Europe.

Classical Coasts. The development of Phoenicia, Greece, and Carthage as Mediterranean trading nations was helped by the limited resources nearby, especially by the lack of grain. The necessity of trading with more distant and backward lands was realized, because raw materials and foodstuffs had to be secured.

Pirate Coasts. Where the people lacked ability to manufacture goods to exchange for food and other supplies, or where the location was unproductive or poor for trade, the inhabitants sometimes turned to piracy as a profession. Certain mountain coasts having few resources and overpopulation bred pirates—the eastern shore of the Adriatic Sea and the hilly coast of Liguria (west of the modern Genoa) in Roman times, Norway in the Middle Ages, and the Barbary Coast in the Napoleonic period. Today the residents of these coasts may emigrate, enlist as sailors, or, like Norway, build ships and carry goods for more fortunate nations. Formerly cities were located inland for protection from pirates with the port a few miles away, as at Athens and Piraeus (Peiraieus).

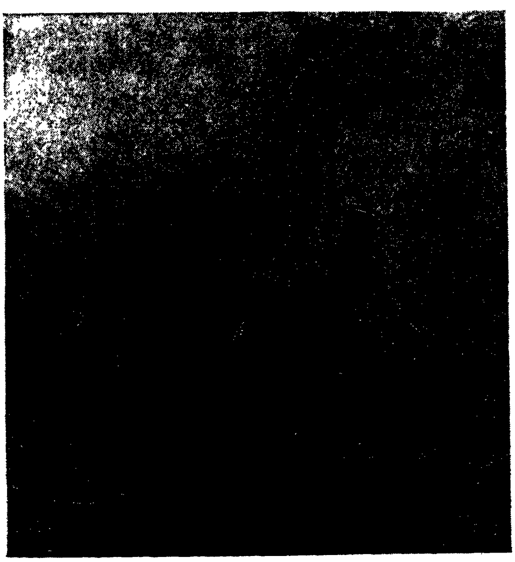

Fig. 184. Commercial whaling vessel operating off the coast of South Georgia in Antarctic waters. The harpoon gun is mounted conspicuously on the bow, and the vessel has a whale in tow. (*Photograph courtesy of the American Museum of Natural History, New York.*)

The Fishing Industry. The life of the sea has been utilized by man for food and other materials since the dawn of history. Great piles of clamshells along the shores of San Francisco Bay and elsewhere show how Indians and other primitive men depended on the sea for food. Polynesians living on islands in the tropical "South Seas" depend greatly on fish and other seafood to supplement their diets of coconuts, breadfruit, and starchy roots. Although fish are abundant in the tropics, the great numbers of different species of fish are more noticeable than the numbers of any one species. The commercial fisheries of the world are based on comparatively few fish and are located where these species are present in vast schools. Generally the shallow waters, a few hundred feet deep, on submarine banks and continental shelves in the cool temperate regions constitute the important fishing grounds. The Grand Banks off Newfoundland, Georges Bank and other banks off New England, the coastal waters from California to Alaska, the Dogger Bank in the North Sea, the coasts of Japan and Kamchatka, the Sea of Okhotsk, and the shores of Norway and Iceland are all important fishing grounds (Fig. 247).

In the United States salmon are the most valuable fish caught. They are secured from the Columbia River, Puget Sound, and coastal Alaskan waters. This migratory fish is taken in vast numbers as it ascends fresh-water streams to spawn and is sold fresh, frozen, canned, and smoked. Seattle, Bellingham, Prince Rupert, Ketchikan, and Juneau are centers for canning, freezing, and shipping salmon.

Gloucester, Boston, and New York are important eastern fish markets for cod, herring, mackerel, haddock, and other fish taken in the open sea. San Diego and Los Angeles pack tuna (Fig. 185), and Monterey cans pilchard ("sardines"). Grimsby, Stavanger, Hakodate, and Brest are among the foreign fishing cen-

FIG. 185. Preparing tuna for canning. These fish are caught by hook and line, brought to the cannery and cleaned; the livers (for making liver extract) are removed. The fish are cut to a convenient size and placed in wheeled racks for steam-pressure cooking before the tuna meat is placed in cans. (*Photograph courtesy of the Los Angeles County Chamber of Commerce.*)

ters. Herring is the most valuable fish caught off the northern European coast.

Fishing is hard dangerous work and breeds a hardy and resourceful people who are the most capable sailors in the world. Often fishermen live along sterile coasts of rock and sand where the land has few resources and man of necessity depends on the sea for a livelihood. Until recently, most of the fish were caught from small sailboats even in the stormy open Atlantic. At present motorboats and steam trawlers are used, or at least an auxiliary engine is added to help the sails. These larger modern boats are independent of the winds and are safer. They can carry cargoes of fish to market more quickly and regularly than can sailing ships. Modern improvements in freezing and shipping fresh fish to inland markets have aided the industry.

Shore fisheries mainly produce lobsters, crabs, clams, and oysters. Matagorda Bay in Texas, and the Mississippi delta are centers of shrimp fisheries. Shallow estuaries and protected coastal waters and lagoons are favored homes for shellfish. Since the numbers of these coastal species can be seriously depleted by overfishing, closed seasons, restrictions on size of catch, and conservation measures may be enforced to protect the fisheries. Also some of the shallow protected coastal waters may be leased by individuals from the state for the planting and raising of oysters. Chesapeake Bay, Long Island Sound, Puget Sound, and parts of the Gulf Coast are important in oyster culture in the United States.

Minor Products from the Ocean. Whales, seals, fur seals (really a sea lion), pearls, pearl shell, and ambergris (used in the manufacture of perfumes) are among other sea products of use to man (Fig. 186).

Minerals include salt, which is often made by solar evaporation of sea water. In recent years bromine, used in ethyl gasoline, has been recovered from the ocean. The light metal magnesium is also made from sea water. Sometimes potash and iodine are extracted from kelp or seaweed.

Kelp provides a substance that is used to keep ice cream smooth and as an ingredient in chocolate milk. Certain types of seaweed are used in manufacturing a gelatinous substance known as *agar*. Perhaps in the future other products derived from the sea will come into commercial use.

and sometimes the waves completely wash over the land. The work of the waves and the wind breaks the coral and heaps the sand up to form a scanty soil in which coconuts and a few other plants will grow. The lagoon and adjacent shallow seas contain shellfish, seaweed, and many varieties of fish. All these are used for food by the inhabitants, who live mostly on the products of the coconut and what they obtain from the sea. The coconut, to the Polynesians living in the South Pacific, is as important as the date palm to the Arab. The tree furnishes the timber for the support of their houses and the building of canoes. The leaves are useful for thatch, for making mats, and for fuel. The covering of the nuts is used for making mats, sails, and cordage, and the nut itself furnishes both food and drink. The meat of the coconut may be dried, and an edible and otherwise useful oil may be pressed out from the dried product, called *copra.* The leafy crown of the coconut may be used for salad, and the sap may be fermented for drinking purposes.

Strategic Islands. Because islands are isolated and may be the only land within a thousand miles or more, they may be of strategic and economic importance. Naval powers, like England, value islands highly for naval bases and fueling stations. Hawaii is an excellent example of a valuable naval base and fueling and supply station at the crossroads of the North Pacific. Islands may serve as bases for transoceanic airplane routes. Thus the American clipper ships utilize islands in their route from Oakland to Asia, stops being made at Hawaii, Wake, Guam, and Manila en route. On the air route from Honolulu to Australia, aircraft use islands like Canton and Samoa. Tiny remote islands have become of high strategic value since the development of airplanes.

In the old days of the sailing ships, the Falkland Islands were a convenient refitting point for ships that had a rough passage around Cape Horn. For vessels carrying goods from Europe to China and back, islands like Ascension and St. Helena in the Atlantic and Mauritius and Réunion in the Indian Ocean were of great value as sources of fresh food, water, and other stores. During the Second World War, Ascension was developed into a major airplane base on the route to Africa.

Islands lying off a populous mainland are oftentimes favored places for carrying on trade, since they are convenient for receiving and reshipping goods from both the mainland and more distant ports. Such a trade center has been called an *entrepôt.* Hongkong and Singapore in Asia and London in England are examples of island entrepôts. Islands, especially where surrounded by swift currents, are difficult to escape from and may be used for prisons, like Alcatraz in San Francisco Bay.

Island Life. Because of their isolation, islands may contain unique examples of plant and animal life that have developed or survived there. Australia, island-like in its isolation, forms an outstanding example of this, for the continent was separated from Asia when only marsupials (pouched animals) existed and before the more complexly organized carnivores and grazing mammals like cattle or deer had evolved. Hence, except for a wild dog introduced by the Australian "blackfellow," the animals were all primitive like the kangaroo; wombat; koala; and platypus, or duckbill, the last an egg-laying mammal. Remote islands like Hawaii or New Zealand and the maze of isles between these extremes in the Pacific contained no native wild mammals except the bat, which could fly, and the rat, which might be carried inadvertently by Polynesian sailors. Bird life, however, was abundant.

Birds. Sometimes, before the arrival of man and other enemies, large birds ceased to fly after arriving at some island; then their wings atrophied, and they became birds of a terrestrial, running type. The moas of New Zealand, the emu and cassowary of Australia, the extinct dodo of Mauritius, and the dinornis of Madagascar are examples. Some diving birds

that nest on isolated islands and inaccessible coasts have lost the power of flight. When these islands are discovered by man, the birds may be so easily killed for their oil that they are greatly reduced in number or even exterminated, like the great auk. The albatross and other birds that obtain their living from the sea commonly nest on the ground and seek remote oceanic islands for their breeding places. Kure and Laysan islands in Hawaii, and Wake Island are examples. The Guano Islands off the coast of Peru and some other islands serve as nesting places for large numbers of birds. As has been mentioned, they may be so arid that the bird refuse accumulates to such depths that it can be mined as the valuable fertilizer, guano. If the climate of these islands were rainy, the guano would be washed away.

Mammals and Reptiles. The harmless sea elephants and fur seals have been exterminated along mainland coasts and now survive only by using breeding grounds on isolated islands. Different sea elephant species use South Georgia and Guadalupe Island off Lower California, and the fur seals use the Pribilof Islands. A South Pacific fur seal, once common on the Juan Fernández group, is now practically extinct.

In the Galápagos Islands (the name signifies "tortoise" in Spanish), each island has its own species of huge land tortoise, but the seagoing form is common to all the group of islands. Isolation accounts for their different evolution. One island having five volcanoes, once separated by water but now joined, has five species of tortoise.

Various lizards have sometimes been preserved on islands after dying out elsewhere. A lizard found only on one small volcanic island off the coast of New Zealand possesses three eyes for some time after birth. Monitor lizards 10 to 15 feet in length exist on one island in the East Indies. Large lizards also are found in the Galápagos Islands. Some of these are seagoing; others live only on the land.

Plants. Isolated oceanic islands generally show few species of plants, since not many types can be carried far over the salt water. The winds and birds carry the seeds of a few types, and fewer still may float. Nearly every tropical Pacific island has pandanus and coconut trees, but it is believed that viability of the seed is soon lost in salt water and that most of these trees were carried by Polynesian migrants and planted on newly discovered isles. Some islands have unique species of plants, like Australia with its eucalypts, Norfolk Island with its "pine" tree, and Lord Howe Island, which supplies seeds for growing the common ornamental palm (*Howea belmoreana*).

Isolation and Health. Peoples on isolated islands develop certain characteristics as the result of their environment. The population tends toward uniformity in appearance and culture because of repeated intermarriage between inhabitants. Without contact with the outside world and the diseases epidemic there, island peoples are healthy and not exposed to contagious diseases. In the Pacific area the Polynesians had no contagious or infectious diseases, and they had never developed any immunity to sickness. As a result, when these islanders were brought into contact with Europeans, introduced diseases like tuberculosis, influenza, smallpox, measles, and blood infections carried off the people at a shocking rate. The population of the Marquesas Islands declined from over 100,000 to a mere 2,000 in a century and a half. It is estimated that three-fourths or more of the numbers of natives living in 1800 in Polynesia, Australia, and Melanesia are now gone. Some islands have lost their entire native populations.

Islands and High Density of Population. Islands having a limited space tend toward overpopulation if the birth rate of the people continues at a normal increase and if freedom from local wars, invasion, and disease protects those born from sudden death. The population of some islands has an extraordinary density. Puerto Rico has as many people as the state of Washington, which is nearly twelve times larger. Barbados supports nearly

160,000 people on only 166 square miles, a density of about 1,000 per square mile. Bermuda has 31,000 people on only 19 square miles, part of which is wasteland. Jamaica's 1,100,000 people have only 4,840 square miles, much of which is mountainous. Another remarkable example of large population is Java, which has 42,000,000 people living on 51,000 square miles of rugged terrain—a density of 820 per square mile. The Javanese live by farming, but the population density is exceeded only by that of small industrial regions like Belgium or parts of England and the most fertile lowlands in China, India, or Egypt. Yet the population is increasing, though only unremitting toil can wring a living from the limited areas of moderately rich volcanic soil and other resources available there.

In Madeira and the Azores the mountains have been laboriously terraced to raise grapes, fruits, and other foodstuffs. The farming is largely hand work, and earnest endeavor is needed to earn a living. Every available square foot of ground seems under cultivation. Landless laborers on overpopulated islands may suffer from unemployment because of inadequate work for them. Sometimes these laborers emigrate to better favored lands. Generally labor from well-populated islands is efficient and capable because only good workmen can survive the strong competition. Thus Barbados Negroes helped build the Panama Canal; Jamaica Negroes help cut the sugar cane in Cuba; and thousands of Portuguese from the Azores have migrated to Hawaii.

Racial Survival. If islands are sterile, very stormy, rocky, or otherwise unattractive for human habitation, they may be left to those who are willing to eke out an existence there without interference. Old languages and cultures may be allowed to endure there. Thus the residents of the little Aran Islands west of Ireland speak almost pure Gaelic, and the Hebrides and other islands off the Scottish coast bear similar remnants of the original Scotsmen. Balearic Islanders speak the purest Catalan.

Breeds of Livestock. Sometimes new breeds of domestic animals originate on isolated islands. If there is a shortage of fodder, natural selection produces small ponies rather than large horses. Thus the Shetland pony developed in the Shetland Islands. When these ponies are introduced into the United States, their offspring often grow larger than in the islands because of the better feed. In the same way the Channel Islands had little grass and needed small cows that would furnish very rich milk. By selection, Jersey Island and Guernsey Island developed the dairy breeds that bear their names.

Plantations. Since islands are readily reached by modern steamships and easily dominated from abroad because of their relatively small populations, they are often chosen as the sites for plantation enterprises. Thus Cuba, Puerto Rico, Trinidad, Hawaii, Java, the Philippines, the Fiji Islands, and Mauritius together grow most of the world's sugar cane. Much cacao (cocoa beans) comes from São Tomé in the Gulf of Guinea and from Trinidad. Coffee is grown in Java and Puerto Rico; tea in Java and Ceylon; rubber in the Netherlands East Indies; cloves on Zanzibar; vanilla in Tahiti; and cinchona, the source of quinine, in Java. When native labor is insufficient, immigrant labor is introduced into plantation islands, which become racial melting pots like Hawaii or have two races side by side that do not mix like the Fijians and Indians (Hindus) in Fiji.

Important Islands near Continents. Small islands near a mainland tend to become part of the strong continental powers, but larger islands that lie off populous and productive coasts and have adequate resources and man power are generally safe from invasion, at least by any means except by aircraft, which has been available only for a few decades. The people of such islands could devote themselves to the arts of peace rather than war, and they often become important commercial and manufacturing nations. England is the

classic example. Sometimes the offshore island group may try to conquer and dominate the nearby mainland politically, as did England in the seventeenth century and Japan in the twentieth century. England, however, prospered most after it abandoned wasting its man power and wealth on European wars and devoted itself to trade.

Problems

1. Why does every country desire good harbors?
2. Why are pilots commonly used on ships when entering or leaving harbors?
3. Why do some harbors need breakwaters?
4. Name several devices by which navigation is aided along coasts.
5. What are some dangers to navigation that radar may help to overcome?
6. What type of coast would you enjoy for a vacation? Why?
7. Why are water bodies generally favored for recreation?
8. What coasts would be favored for winter resorts?
9. Why are atolls found only in low latitudes?
10. What inventions have given importance to remote oceanic islands in recent years?
11. Why are the epicontinental seas the scene of most of the world's important commercial fisheries?
12. What peculiarities of food fish make them (*a*) desirable or (*b*) undesirable for human consumption?
13. What bodies of water do the following straits connect, and why are the straits important: Gibraltar, Bab el Mandeb, Malacca, Dover, Belle Isle, Torres, Skagerrak, Magellan, Bosporus, Kerch, Dardanelles, Messina, Hormuz, Florida, Korea.
14. The following islands are located in particularly strategic positions. Analyze each, and indicate its strategic importance: Newfoundland, Sicily, Azores, Crete, Iceland, Malta, Faeroes, Bornholm, Rhodes, Ceylon, Formosa, the Aleutians, Madagascar, Tasmania, Hawaii, Sumatra, Cuba.

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CHAPTER 17: *Soils and Soil Conservation*

Soils constitute one of the most important factors in geography. Compared with the whole volume of the earth, soils form but a small film only a few inches to several feet in depth on the surface, yet this relatively thin layer produces nearly the entire food supply of man. Warlike invasions and peaceful migrations have occurred almost numberless times during human history, when man began his search for areas of fertile soil. The power and the population of a nation depend to a great extent on the area and fertility of its soils. The westward expansion of the United States was largely dominated by the need and desire for more fertile farm lands. In the past, peoples and kingdoms have risen and attained great importance in the civilized world, only to decline in numbers and influence with the careless destruction of soils by erosion and by reckless farming methods. Certain lands tributary to the Mediterranean form outstanding examples, as well as some worked-out and eroded lands in the "Old South" and in the loess hills of northern China.

Soils

Origin of Soil. Soils have a very complex origin and result from the interaction of many different factors. The most important of these are the kind of parent material from which the soil was formed; rainfall, temperature, and other climatic influences; natural vegetation; relief of the land; drainage; animal organisms living in the soil; bacteria; and the length of time during which the various factors have worked together to create the soil cover. The decay and disintegration of the bedrock furnish the original material of which soils are made. The weathered fragments, called *mantle rock*, form the basal material from which develop the *residual soils*, which are formed in place. Soil may also be derived from *transported* material deposited by running water, glaciers, winds, and waves. Residual soil changes gradually from the bedrock through broken mantle rock into the subsoil and surface soil, but a transported soil may differ entirely in character from the bedrock over which it lies. It is obvious that the original character of soil will be determined by the kind of material from which it is derived, but other agencies may cause a soil to change its original character so greatly, that after a long time, similar soils may develop from entirely different bedrock, or different soil types develop from similar bedrock. In general, soils in which the parent material dominates are youthful, and those materially modified by various agencies are mature.

Contrasts in Humid and Arid Soils. The most important factor affecting soil character is that of climate. In well-drained ground, there is a steady downward percolation of water in areas of abundant precipitation. This ground water contains a weak solution of carbon dioxide, which is obtained from decaying organic material. Such a solution can dissolve and carry away lime and other salts in the ground. Thus in a region of abundant rainfall and good drainage the soil becomes *leached*. In regions of deficient precipitation the rain water penetrates but a few feet underground. There lime and other salts dissolved in the water are deposited in the soil when the water evaporates, building up a zone of lime accumulation from one to several feet beneath the surface. When present in a dense layer, this zone may be called *hardpan*.

A generally accepted modern classification of soils divides them into *pedalfers*, formed under humid conditions, and *pedocals*, formed under arid and semiarid conditions. These names are derived from the chemical symbols of aluminum and iron, characteristic of

leached soils, and of lime (calcium carbonate), characteristic of arid soils. In the United States the line separating the pedalfers and pedocals runs from northwestern Minnesota to Corpus Christi, Texas. East of this line, mature soils without exception are pedalfers and form under humid climatic conditions. West of the line, pedocals predominate, and pedalfers occur only in the rainier areas, especially in the Pacific Northwest.

Soil Horizons and Maturity. Soils go through a series of changes by which the original freshly accumulated rock material becomes greatly altered. This finally results in the development of zones, or horizons, in the soil, each having its own characteristics and each differing markedly from the unchanged material beneath (Fig. 188). When this stage has been reached, soil is said to have attained maturity. Soil scientists (pedologists) called the topsoil the *A* horizon, the subsoil the *B* horizon, and the slightly changed mantle-rock material the *C* horizon. Soils are classified by the character of these different horizons; their composition and color; the size of soil particles or texture of soil materials—sand, loam, or clay; and the structure, which depends upon the arrangement of the soil particles. Soils that are waterlogged most of the year or are impregnated with alkali do not develop the normal characteristics or profile of a mature soil, since the stagnant water prevents normal leaching and weathering. Neither do soils on steep slopes develop mature characteristics, since excessive erosion removes the soil before it has a chance to attain maturity.

Effects of Plants and Animal Organisms on Soil. Natural vegetation is another important factor in soil formation. Where the climate favors the growth of tall prairie grass and herbs, the resulting abundant stems, leaves, and roots furnish rich humus, which gives

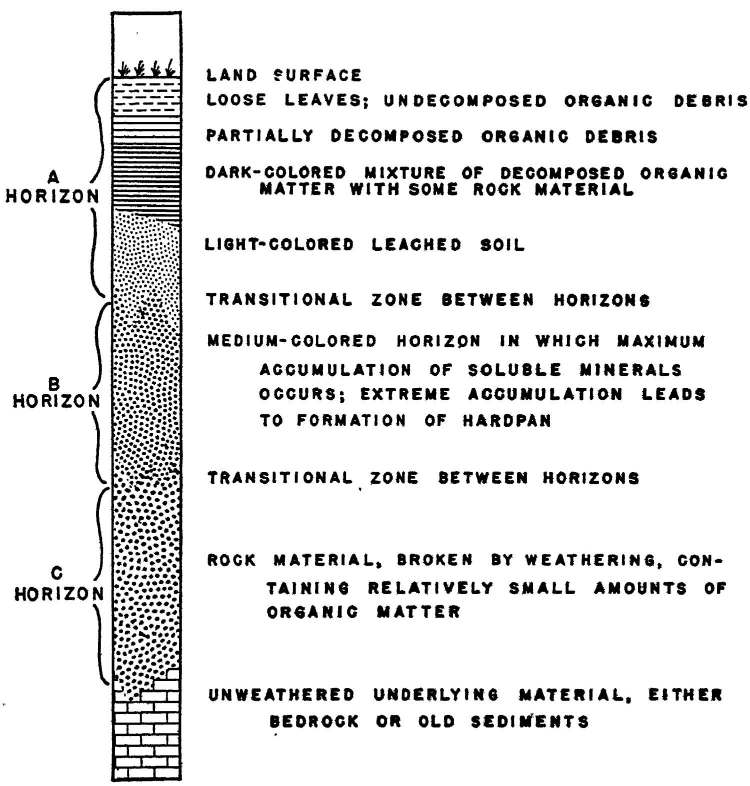

FIG. 188. Soil profile (hypothetical) showing principal soil horizons developed under humid conditions. Not all horizons are found in all soil types.

soils a dark color like the prairies of Illinois, the soil of the Red River Valley, and the famous black soils in Texas and Russia. Various animal organisms such as earthworms also live in the soil and by their activities change dead vegetable matter into soluble nutrients for plant life; furthermore earthworms have a material effect on soil structure or aggregation of soil particles. The bacteria, fungi, and other members of the biological world produce most important effects in the formation of soil by helping in the decay of organic matter, the development of humus, and the formation of soluble compounds that can be used for food by plants. The leaves from hardwood forests are rather readily incorporated in the ground by bacterial action and generally produce more productive soil than that which develops on ground covered with coniferous needle leaves containing too much pitch to decay readily and become incorporated in the soil.

Life History of Soils. Soils pass through a life cycle. Those which have been formed recently are said to be in the stage of infancy. Youthful soils are characteristic of flood plains and recent deposits of both lava and volcanic ash. Such young soils, even in a rainy climate, are likely to be fertile, since the leaching action of percolating rain water has not had time to become effective. Mature soils are those in which the effects of rainfall, natural vegetation, biological life, and other factors have developed certain acquired characteristics, rather than those originally derived by the soil from its parent material. Mature soil has reached a stable condition and changes little thereafter. Since mature soils are the end products of all the numerous factors acting upon them, they occur mostly on level plains and plateaus where erosion has small opportunity to disturb the soil-forming processes, and rarely in hilly or mountainous regions where erosion is active. The actual type of soil developed in such places depends upon all the factors that joined to produce the change, and the time that elapsed while these factors were operative.

Generally the *A* horizon is richest in organic matter, since most of the roots and the greater part of the humus are found there, along with most of the organic life. This normally gives the *A* horizon a darker color than the *B* horizon (Fig. 189). As the humus decays, nitrates and potash are released in a soluble form that can be used by plants. The *A* horizon is not always fertile; for example, the soil that is formed under the climatic conditions supporting the coniferous forests of the Northern Hemisphere tends to be so leached that the lower part of the *A* horizon consists of a gray sand lacking in fertility. This soil was named *podzol* by the Russians.

Texture and Structure. Important physical properties of soils are texture and structure. These affect the absorption and retention of water and hence are factors in the growth of crops and natural vegetation.

Soil texture is concerned with the size of particles in the soil. Some soils are largely coarse gravel and broken rock, while others consist largely of sand, silt, or clay in order of increasing fineness of particles. Coarse soils permit the rapid percolation of water, and the natural vegetation should be of a drought-resistant nature. Fine soils are highly retentive of water, to such a degree in the case of clay that during wet seasons the plowing and cultivation of the soil become difficult. Because of the large total of surface areas afforded by fine particles, silt and clay soils provide more accessible and extensive ground water for plants than do gravel or sand. Mixtures of fine and coarse materials may form desirable soils; one of these, called *loam*, is formed from sand, silt, and clay. Very small particles of clay are sometimes said to be of colloidal size, but the term also includes colloids of organic origin. Mixed with the minerals or rock particles are colloids, organic remains, living organisms, water, and substances in solution, all of which together help to determine the texture and other characteristics of the soil.

Another factor of importance affecting plant growth is the availability of water in

FIG. 189. Road cut in the Palos Verdes Hills, southern California, showing the sharp contrast between bedrock (*C* horizon) and residual soil (*A* horizon). In this case the *B* horizon is almost entirely lacking. The short grass vegetation cover of these hills is typical of the drier parts of the Mediterranean climatic lands. (*Photograph by Anton Wagner.*)

the soil. Soil texture helps to determine how readily plants can obtain this water. Sands, silts, and clays differ in their retention of water because of differences in the film tension that holds the water to the soil particles.

Air is present in soil and is necessary for the growth of the organisms forming humus from the raw vegetable matter; it also performs other functions to prepare the soil food materials for plants. Water may occupy the openings between the soil particles. If it moves freely downward, it is called 1 *gravitational water*. This feeds springs, wells, and artesian flows. That which is held in small openings is called 2 *capillary water* and is the chief source of supply for plants. Since capillary water may evaporate, its retention for use by crops is the basis for "dry-farming" methods. Water that tightly adheres to soil particles is called 3 *hygroscopic* and has negligible movement in the ground.

Structure is the arrangement of soil particles; it affects the penetration and movement of water and the availability of the soil nutrients to plants. In a good soil structure the particles are joined to form granules, or floccules, that favor the necessary circulation of air and water. The granules may themselves be arranged in various ways. Soil structures may be granular, crumb, columnar, prismatic, platy, or irregular, angular, fragmental material. Soil structure that is favorable for plant growth may be injured by wrong methods of tillage, by the exhaustion of humus and lime, and by other abuses. The pore space of a well-aggregated loam soil is 35 to 50 per cent. When this pore space has been reduced by cultivation and in other ways, the entrance and movement of air and water are limited,

and the soil may then become dense, thus reducing crop production. Loss of humus following the continuous cropping of wheat lands from which straw has been removed or burned often allows the drifting and blowing away of the soil particles because of the deterioration of the soil structure. The humus serves to hold the soil in well-aggregated form. Farm systems should be oriented toward maintaining desired soil structure.

Color. The color of soil is a minor characteristic that helps to indicate soil origin and fertility (Fig. 190). The red and yellow colors reflect the presence of minerals, usually iron in some form. The blackness of soil usually is in proportion to the humus content, produced by organisms from decaying plant material. Reddish-colored laterite is a common tropical soil resulting from rapid oxidation processes, leaching of other minerals faster than those of iron, and lack of organic matter that insects and agents of decay rapidly destroy. Light-colored soils may be the result of leaching in cool rainy climates. Other light-gray-colored soils occur in deserts where scarcity of plant life means that humus is unavailable. Some desert soils contain an excess of alkaline salts, which inhibit the growth of most vegetation. An excess of alkali also injures the soil structure to an extent that farming is handicapped.

Soil Types in the United States. In the United States thousands of different soil types exist, having characteristics by which they can be distinguished from each other. The outstanding mature soil groups in this country, however can be reduced in number

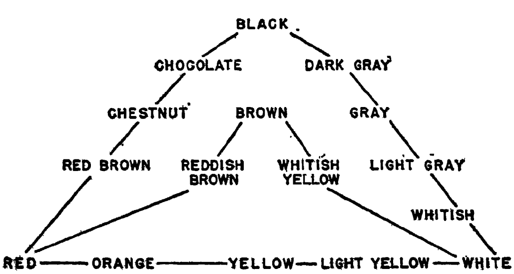

FIG. 190. Soil-color relationships. Note how the different colors blend.

to seven main groups (Fig. 191). Those formed under humid conditions, the pedalfers, or non-lime-accumulating soils, are the podzols, the gray-brown forest soils, the red-yellow forest soils, and the prairie soils. The leading types of pedocals formed outside the forested areas are the black earth, dark-brown earth, light-brown earth, and the gray desert soils. Other soils are the undifferentiated types of the mountainous regions, swampy areas, and the sand hills of Nebraska and other similar areas. Different phases of the soil types are recognized, depending on texture, structure, and chemical composition, especially whether they are lime-accumulating (pedocals) or non-lime-accumulating (pedalfers).

The Pedalfers: Non-lime-accumulating Types. Podzols. Podzols are the badly leached soils that develop typically in parts of northern Michigan, northern Wisconsin, northeastern Minnesota, and northern Maine. Somewhat similar soils are also developed on pervious gravels and sandy deposits in the rainier parts of the Pacific Northwest. The largest extent of podzol soil appears as a broad belt occupied by the taiga of northern Europe, Asia, and North America. Podzols generally develop under a cover of conifers. They are so thoroughly leached that their resulting low fertility makes them unattractive for farming. The topsoil (*A* horizon) has lost most of the soluble plant nutrients, and the subsoil (*B* horizon), while also low in fertility, may actually be the more fertile (Fig. 192-A). Agriculture is usually of slight importance in regions with podzols, and the main industries consist of lumbering, fishing, trapping, or mining. The farm crops are often of a subsistence character for local consumption; they include oats, barley, rye, potatoes, and root vegetables. Hay can usually be grown with some success, and exports coming from the farms may consist largely of dairy products. Many farmers, unable to make an adequate livelihood on podzolic soils, have abandoned their farms and deserted large areas once

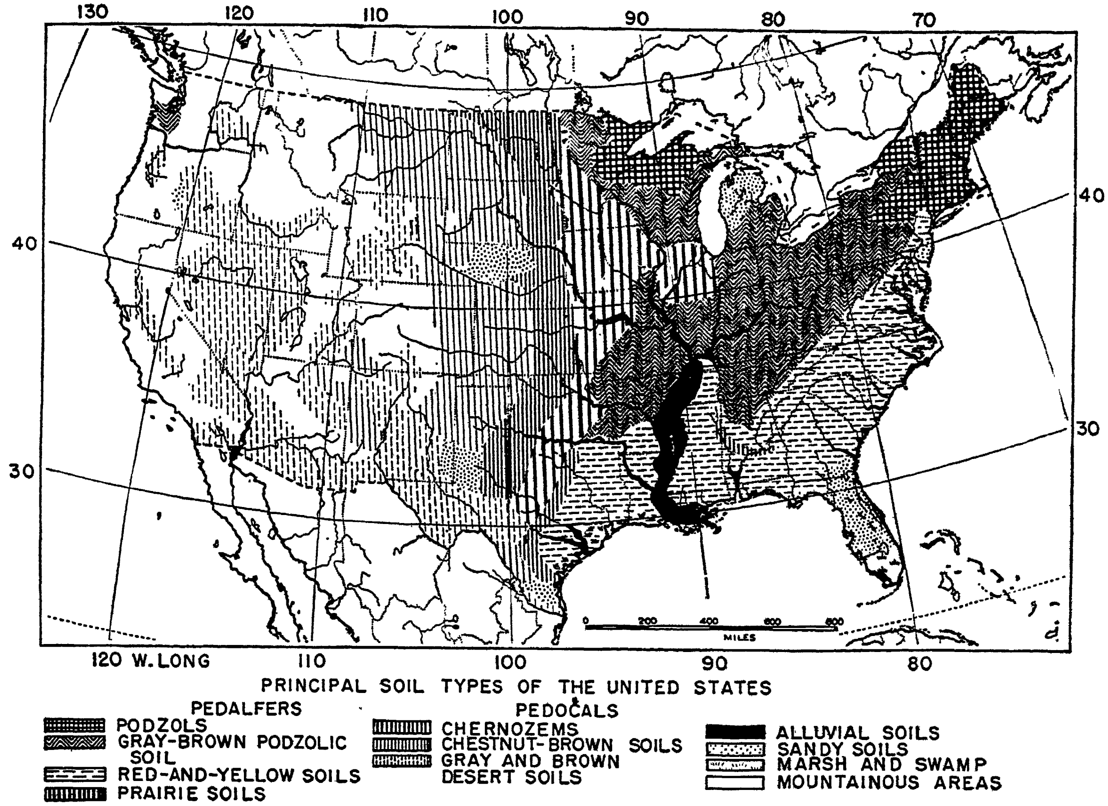

FIG. 191. Principal soil types of the United States.

cleared for cultivation, as in parts of northern Michigan.

Gray-brown forest soil. The gray-brown forest soils developed in the rainy mid-latitudes, where the principal trees consisted of broad-leaved species. This soil group has a lower acid content than the podzols, is less leached, and can retain water better. The soil is reasonably high in humus, and the *A* horizon is brown in color, with the *B* horizon of lighter color and rather compact structure (Fig. 192-B). The gray-brown forest soils cover the northeastern United States east of the prairies from the Ozarks and southern Wisconsin to Virginia and southern New England. When care is used in cultivation, gray-brown soils are productive and easily tilled. Except in regions that are too rugged for farming, most of these soils have been cleared of forests and brought into productive farm land. By rotation of crops, their fertility can be maintained, especially where a crop of clover is plowed under every 3 or 4 years. A large variety of crops is raised on these soils, from the crops like wheat, corn, small and large fruit, and tobacco, to the fodder crops for livestock.

Red and yellow forest soils. The red and yellow forest soils are characteristic of the southeastern United States and have developed under rather high rainfall conditions, long growing season, and hot summers. Various species of pine trees form the predominant native vegetation, but oaks and other hardwoods frequently occur. In general the soils show evidence of considerable leaching, since the winters are too mild for freezing the ground and ground-water percolation continues throughout the year. The yellowish phase is especially leached. This soil is developed

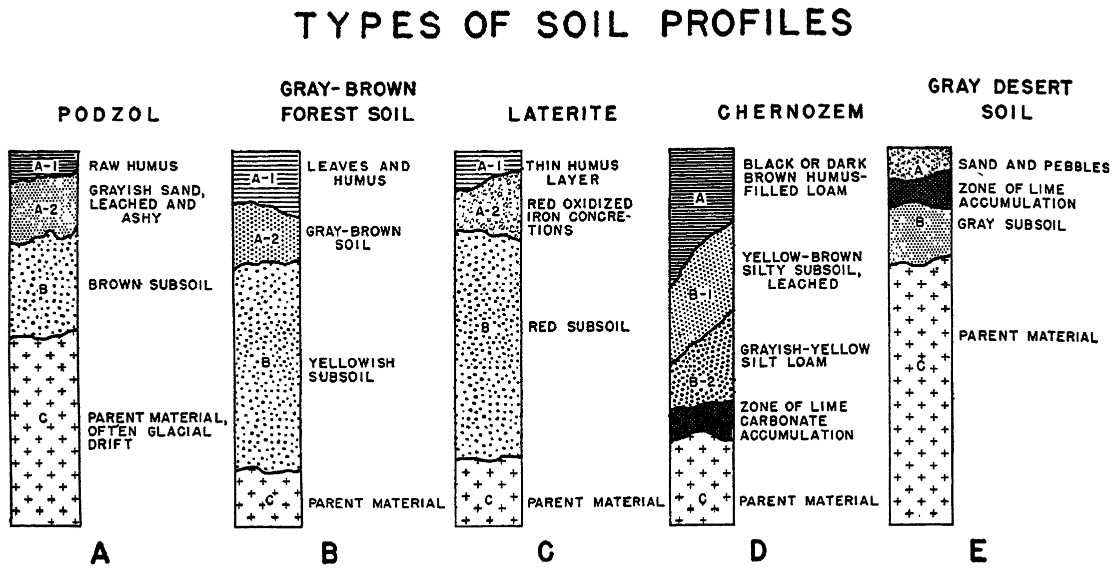

FIG. 192. Types of soil profiles.

in a rainy climate and long growing season under a vegetation cover of southern pines. The redder soils are more often associated with the deciduous trees. These soils are easily cultivated, but the fertility is low and constant cropping soon exhausts their productivity, as large areas of abandoned farm land in the South attest. Specialty crops like fruits and vegetables for the northern market and sometimes cotton or tobacco may be raised on the poor soil if enough commercial fertilizer is added. The raising of peanuts, field peas, and other legumes in rotation with crops that exhaust the soil has proved advantageous.

Possibly a change in the farm economy of the South might be utilized to improve the productivity of yellow and red soils. Where cultivated fields are too hilly, the heavy rainfall causes very destructive gullying and sheet erosion on areas of light yellow to red soil. More careful cultivation of the ground and wider use of the crop-rotation system of farming should be used to maintain and build up these soils.

Lateritic soils. In the tropics, a deeply weathered reddish soil develops under conditions of heavy rainfall, high temperatures, and dense forest growth (Fig. 192-C). These soils, called laterites, characterize the tropics and are generally of low fertility because of excessive leaching. Some of the forest soils in the southeastern part of the United States resemble the laterites and may be termed lateritic. Laterites consist largely of aluminum and iron oxides which have accumulated, and these soils are red in color because of their high iron content.

Brazil, central Africa, and southeastern Asia have large areas of laterite soils, requiring extensive use of fertilizers to maintain good crop yields if they are used for agriculture. Some lateritic soils formed from volcanic materials are comparatively fertile because the continuing decay of the soils restores the minerals needed by plant life. This is the case in parts of Hawaii and in Java.

Prairie soil. The most fertile soils formed under humid conditions are those developed on the nearly level grassy plains and slightly rolling prairies of Illinois, Iowa, and adjacent humid prairie regions. The black prairie soils are rich in humus, retentive of moisture, deep, and productive; and, by means of crop rotation and prevention of erosion, their fertility can be maintained almost indefinitely. These deep rich prairie earth soils are

among the most fertile farm lands in America. The Corn Belt in part and much of the winter wheat belt occupy land covered with this soil group. The large farming population that this soil supports, together with the numbers of farm animals it maintains, are further evidences of its fertility. The black prairie soils of Texas and Oklahoma are the most important cotton lands of those two states and produce more than double the yield per acre of the leached yellow and red soil of the coastal plain. Certain youthful soils in the Yazoo Delta, the Mississippi flood plains, and the famous "Black Belt" of Alabama and Mississippi are deep and highly fertile, since the alluvial materials of which they are composed are too recent in origin to have suffered leaching; hence they still have great productive capacity.

Pedocals: Lime-accumulating Soil Types. Chernozem soil. The black earth, or chernozem soils, are among the most productive grain lands in use by man. These soils develop on prairies having adequate but not excessive rainfall, where natural conditions favor the growth of grass rather than trees (Fig. 192-D). Such soils belong with the semiarid pedocal type because they possess a zone of carbonate accumulation a few feet below the surface of the ground. Chernozem soils in Russia often have a thickness of from 4 to 6 feet at the topsoil or *A* horizon extending over large areas. In the United States, the black portion of the soil is usually only from 1 to 2 feet in thickness. These chernozems occur in a zone extending from the Red River Valley in western Minnesota and eastern North Dakota southward through Kansas and central Texas. Locally they occur in the Far West and include the excellent Palouse soil of eastern Washington and adjacent regions used for wheat production. Formerly devoted to livestock, the chernozem soils have proved so good for wheat and other grains that farmers have usually replaced stockmen, and the former grazing land has been changed into productive farms. The crops naturally vary with the length of the growing season. On the Great Plains, spring wheat occupies the black soils of the Dakotas, while winter wheat is the principal crop for such lands in Nebraska and Kansas, with winter wheat, sorghum, and cotton in Oklahoma and Texas.

Brown earth soils. Adjoining the chernozem soils, where precipitation is less and the tall prairie grasses are replaced by short grass and bunch grass, occur the brown earth soils which have both dark- or reddish-brown and light-brown phases. These soils occupy most of eastern Montana and the western parts of the Dakotas and Kansas as far south as Oklahoma and the "panhandle" of Texas. They also occur in those parts of the Columbia Basin between the Cascades and Rocky Mountains in areas having a precipitation of about 10 to 15 inches annually. These soils originally supported short grasses and in a state of nature afforded excellent grazing for cattle and sheep. When first cultivated, crops of wheat are generally successful on the light-brown soil, but the humus that binds the soil particles is soon exhausted, and then in dry seasons the soil may drift away with the wind. Once it was common practice to burn off the straw after harvest, but it has been found that plowing under the wheat stubble maintains the humus content of the soil. This and other improved methods of tillage have reclaimed "blow land" on these light soils (Fig. 195).

Gray desert soil. The desert soils generally develop on less than 10 inches of rainfall and are gray in color because of their lack of humus materials (Fig. 192-E). The zone of lime accumulation is thick and nearer to the surface than in the case of the light-brown and black pedocal soils. Only under exceptional circumstances can gray desert soils be cultivated for wheat and other crops without irrigation, and attempts to farm such areas have universally resulted in failure, as is evident from the many abandoned farms on the gray soil of eastern Colorado, northern Montana, southern Idaho, and the Columbia Basin in Washington. Desert soils, though low in humus, have not had the soluble salts leached by rain water; desert soils may there-

fore become very productive when irrigated. Without irrigation, the chief dependence is on grazing, and only a few stockmen can be supported, since the herds can obtain forage from the sparse vegetation only if large areas per animal are available. Often 40 to 80 acres per steer are required in dry-land areas, in contrast to several animals to the acre on a well-watered meadow.

Utilization of Soil. Since more people directly depend for a living on agriculture than on any other industry, the use of soils for farming is a matter of great geographic importance. Proper land utilization requires the selection of crops best adapted to the different soils, the development of farming methods to maintain the productiveness of land for agriculture, and the handling of grazing and forest land so that these resources are not quickly depleted.

The plants that are best for any given set of geographic factors may be determined by experimentation with many types of plants in various soils and under different climatic conditions. Sometimes new plants developed by plant-breeding experiments provide improved varieties better adapted to conditions than any previously available. Of course, under certain market conditions, it may pay to raise a crop in areas not ideally suited for its production, as in the case of berries and vegetables that are grown near large cities where they can be marketed at a profit. Some tomatoes and other types of produce are grown in hothouses near city markets during the winter. On remote islands like Wake, or in arctic regions, vegetables are sometimes grown in small quantities in chemical solutions. Some nations, greatly in need of a particular crop, such as sugar beets, may try to stimulate production uneconomically by the application of high protective tariffs, by the payment of bonuses, or by some other method.

Changes in Agriculture. Under pioneer conditions in the United States and in many industrially backward parts of the world today, farming is on a subsistence basis; that is, each farmer tries to raise all the food and as much as possible of other things that his family requires, even if local conditions are unfavorable. The family consumes almost all that is thus produced, and little attempt is made to grow a surplus for sale or trade.

As civilization develops, steamships, railways, and highways are provided for the exchange or export of commodities. Then farmers generally prefer to specialize on one or more staple crops that are most profitable under local conditions. They exchange their surplus for other needed products and cease trying to produce everything that is needed on each farm. By concentrating on a staple article in good demand, producers in different regions become skillful in raising certain crops and build up a large demand for their product, which may be widely distributed to markets. Examples include grapefruit grown in the Rio Grande Valley in Texas, canned pineapple in Hawaii, apples in the Wenatchee and Yakima valleys in Washington, oranges in California and Florida, and dairy products in Denmark.

The different crops raised, whether cotton, corn, wheat, orchard fruits, tobacco, or other staples, cause decided changes in the landscape. The buildings, size of fields and farms, and the number and kind of livestock are related to the money crop of a region. The buildings of a Corn Belt farm would include a big barn for storing hay. Many windows on the ground floor indicate the locations of stalls used for the cows and horses. High round silos and many sheds for pigs, poultry, and machinery are located nearby. In California with its mild winters, storage of hay is done in the open for the short period of feeding during the dry season, and silage is not needed. The barns are small, since the cows can spend most of the seasons in open pastures. In New Zealand dairy country the same lack of barns is noticeable, since green feed is available throughout the year. In tobacco country, sheds with adjustable openings for curing the leaf are characteristic features of the farm complex. Each farming region has its own effect on the cultural landscape.

Soil Maintenance. Plants secure minerals for their growth from the soil. Steady planting of any staple crop year after year exhausts the supply of soil nutrients and results in decreased crop yields. Though a change in the crop planted will usually help temporarily, since different plants have somewhat different food requirements, ultimately most soils become so depleted by steady cropping that yields decrease until farming becomes unprofitable and the farm may be abandoned. The Soil Conservation Service estimates that erosion on sloping lands takes away fertility elements five to twenty times faster than depletion by cropping. With change in the farm system, soil fertility can be maintained and even increased. Commercial fertilizer may be added to enrich the soil and increase crop yields. This is practicable only when crop yield response is equal to or greater than the cost of fertilizer, since most staples must sell at low prices. Animal manure, wood ashes, crop residues, and other organic wastes add needed nutrients to soils. Crop rotations should include green manure and meadow containing various legumes like alfalfa and clover, which have nitrogen-fixing bacteria on their roots and thus improve the soil while producing useful fodder and food crops.

Because different soils require different handling, the successful farmer must scientifically study the soil of his farm and develop a soil and water management system that will produce a comfortable living while maintaining soil fertility for use by future generations. Reckless exploitation of soil by depleting, cropping, and erosion followed by land abandonment and local depopulation must cease if the United States would remain a great and prosperous nation, since soils are the most fundamental resource of our land.

Relation of Civilization and Culture to Soils. In general the stage of civilization is higher in regions of fertile soils than in those of poor soils, since good land means successful farmers who can afford schools, highways, houses, automobiles, and other conveniences of life. In most regions having both good and poor soils the leaders of society and the aristocracy develop on the fertile land, but democratic leaders and movements more often start among the residents of poor land. In states like Kentucky and Tennessee there are strong contrasts in wealth, culture, politics, and even religion between the people living on small farms with poor soil in the hilly uplands and the well-to-do residents of the Bluegrass region, Nashville Basin, and Mississippi flood plain who receive a good income from large and fertile farms. Similar contrasts are common elsewhere.

Since a fertile farm of good size can support both the owner and a tenant, a considerable increase in tenantry has occurred in some parts of the United States. Few tenants will maintain the soil so efficiently as an owner, and soil depletion often results from the tenants' common practice of raising cash crops rather than diversifying. Parts of the Corn Belt could well serve as examples of this practice. In the Cotton Belt of the South, areas of rich soil like the Black Belt of Alabama formerly had many large plantations operated by slaves. Today they are worked by tenants, mostly Negroes. Thus the most fertile black soil has a preponderantly colored population with a small number of whites who own most of the land and manage affairs.

Most great nations of the world have considerable areas of productive land. Today they may import some of their foodstuffs, paying for them by the profits from trade and industry, but nearly always there is a core of fertile land around which the nations grew and in which its people developed their culture. France, England, the Netherlands, and many other countries of Europe are examples. The accumulations of wealth would be more common in the fertile regions. Here men with wealth would use their leisure to develop culturally and to encourage progress and learning in many fields. The refinements and developments that we commonly call civilization are most obvious in large cities and wealthy nations, generally in those that pos-

sess or have access to productive areas of fertile soil. It should be mentioned, however, that the virtues which are admired more often than those possessed by a wealthy leisure class are frequently the very ones that are characteristic of some mountain people and others with limited economic opportunity.

About 4 billion acres of arable land in the world are available now to the farmers. Much of this land is poor to medium in quality. The world population is about 2 billion, which allows 2 acres of tilled land for the support of one person. The necessity of maintaining soil fertility and preventing erosion and other causes of soil depletion is apparent if the people of the world are to be well fed.

Soil Conservation

Soil Erosion. The conservation of soils is recognized as absolutely essential to the maintenance of civilization in any region. Where soil, through carelessness and neglect, has been allowed to wash away, as in land tributary to the Yellow River in China and on land adjacent to the Mediterranean Sea, we find once densely peopled places now depopulated and a condition approaching that of the deserts. Even in the United States, where farming has been carried on a comparatively short time, it is estimated that 50 million acres of land have been so badly washed that they have become of negligible use for agriculture. Nearly 100 million additional acres have suffered severe damage from erosion. This is especially important, since it requires several centuries to form an inch of soil and may require several thousands of years for these lands to become stabilized and for soil of workable depth to accumulate again.

Forms of Erosion. Erosion of soil results from sheet erosion, gully erosion, stream erosion, and wind. Sheet erosion, the repeated removal of a thin layer of soil from the top of the ground, resembles the skimming of cream from a pan of milk, since the richest soil is usually on the surface (Fig. 193). Sheet erosion is insidious, since most farmers hardly realize that their fields are being damaged. Gully erosion results from runoff in myriads of little drainage channels that unite together and finally wear a deep gully, which by growing headward may so divide a field that tillage is made difficult (Fig. 194). Streams oftentimes destroy farm land by lateral erosion, which undermines their banks and allows the soil to slide into the water. In times of flood, a river like the Missouri may destroy half a cornfield in a single flood. Wind erosion usually begins when soils in dry regions like the Great Plains have had their structure destroyed by unwise cultivation or have had their surface protection removed by overgrazing. Once the process is started, blowholes are excavated by the wind, and dunes travel to leeward with the air currents, creating a damaging condition that is difficult to control (Fig. 195).

Factors Affecting Erosion. Soil erosion is most rapid on sloping land subject to heavy rainfall, especially when the rain is of a torrential character. In a state of nature the trees, shrubs, grass, and decaying plant litter help absorb the rain impact energy and retard the runoff so that erosion is not rapid enough to do damage. Early settlers on the Atlantic coast remarked on the clarity of the streams, and it was only after the land had been cut over and cultivated that erosion gave the streams the muddy character they have today. The custom of plowing and of cultivating up and down the slopes instead of along contours promotes erosion. The destruction of vegetation by livestock and the creation of paths and ruts may concentrate the runoff and lead to gully formation. The type of soil also influences the runoff and resulting erosion, some soils being more absorbent, permeable, and resistant to erosion than others.

Erosion is a special problem in the hilly parts of the Piedmont Plateau and rolling lands included in the coastal plain from Virginia through the Carolinas, as well as in

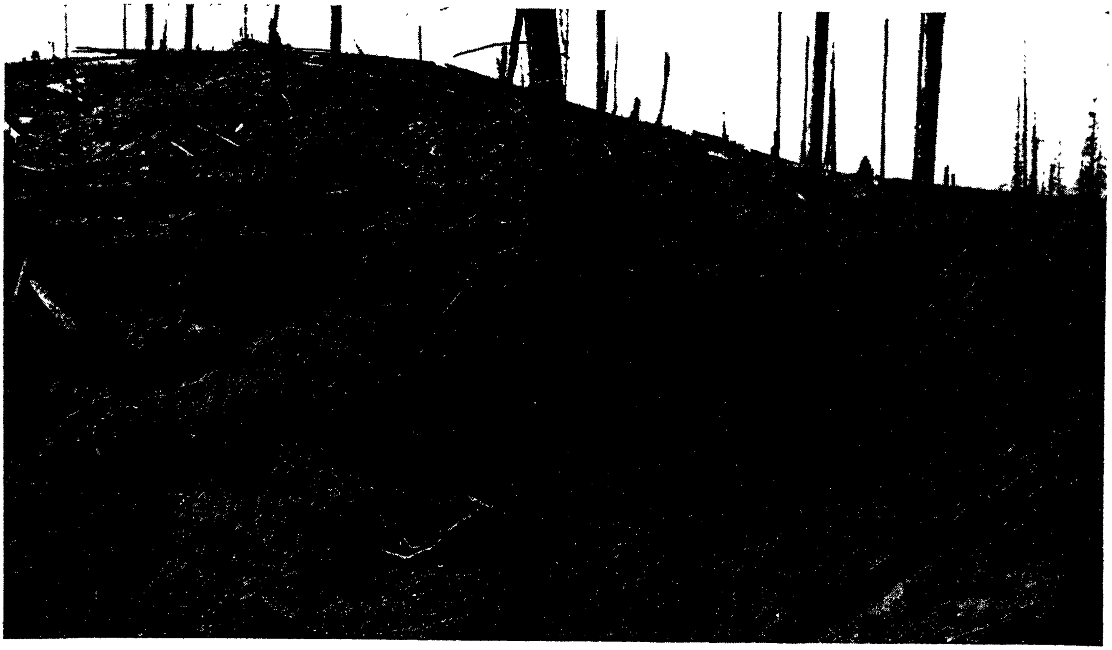

FIG. 193. Typical sheet erosion on northern Idaho burned-over forest lands. This unprotected soil washes rapidly. Reforestation and grass seeding would restabilize these badly burned areas. *(Photograph courtesy of the U.S. Soil Conservation Service, Department of Agriculture.)*

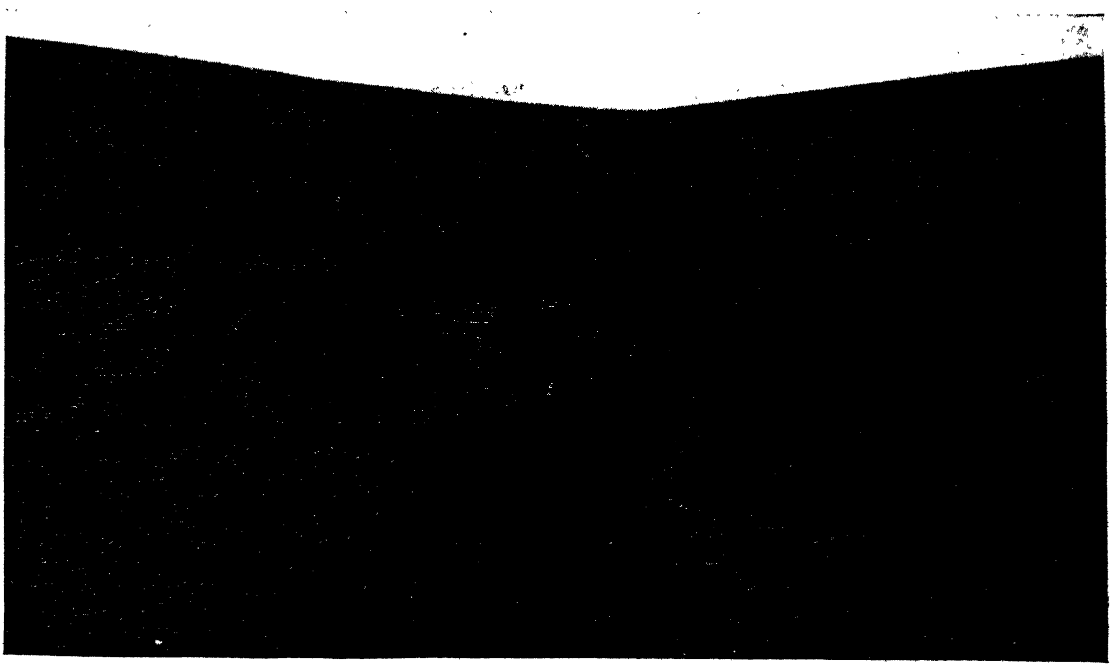

FIG. 194. Severe washing in winter wheat land in the foothills of the Blue Mountains of Oregon. A 48-hour wash from a 40-acre drainage area on a 5 per cent slope cut this gully 8 feet deep and 15 feet wide. *(Photograph by J. G. James, courtesy of the U.S. Soil Conservation Service, Department of Agriculture.)*

Alabama, Georgia, and Mississippi. It is also serious on cleared areas of the Appalachian Plateau regions, the glacial hills around the Great Plains, and sloping land surrounding the Ozarks. Severe soil erosion is affecting many farms in the Corn Belt, in part because of tillage methods and insufficient rotation of crops. Parts of southern California have been very severely damaged by erosion, as have parts of the intermountain wheat sections of Washington and Oregon.

Effects of Erosion. The erosion of topsoil on hilly land usually results in its removal from the brow of the hills and steeper slopes, where the soil is thinnest and therefore most needed. It is deposited on the bottom lands, where the usually fertile soils need enrichment least. Some fine soil is carried away to the lakes and oceans. After some years of such erosion, the reddish clay subsoil is all that remains on the hill summits, and the farming of such slopes has become unprofitable even if gullying has not sooner destroyed its usefulness for agriculture. In some parts of the country these eroded hilltops are known as "balds." When gullying begins, the infertile and stony subsoil is washed away, and it may be dumped on fertile bottom land, thus completing the ruin of a region. In addition, streams and reservoirs are filled up with silt from the washing of the heavy rains. In this way channels and reservoirs used for irrigation often have their storage capacity lessened. Several reservoirs in the piedmont area in the southern United States have been so filled with silt that they have been rendered useless, and reservoirs on the Rio Grande project which have been in operation only 30 years have already lost nearly one-third of their storage capacity from silting. Sudden

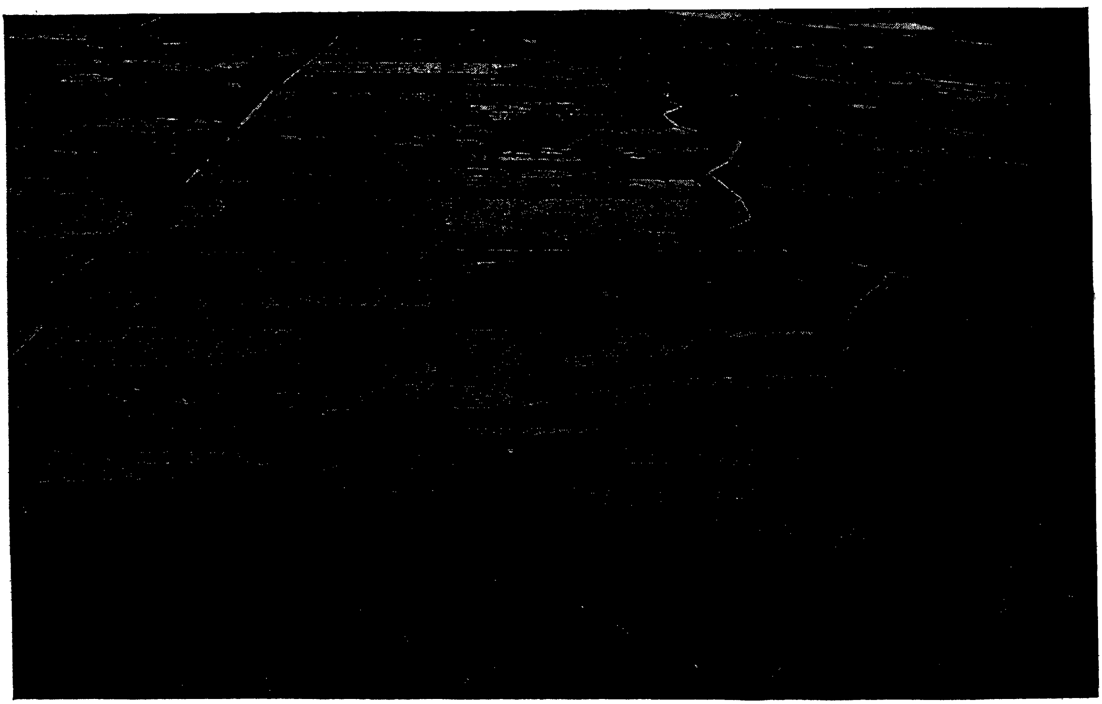

FIG. 195. Looking eastward over irrigated and unirrigated land near Irrigon, Oregon. Undeveloped raw sagebrush land appears at the right. These lands are highly subject to "blow" damage, even the raw lands showing occasional active sand dunes. Under cultivation the wind problem is so severe that windbreaks of Lombardy poplars are planted at intervals to prevent soil movement. Most of the windbreaks extend in a north-south direction to break prevailing westerlies. (*Photograph by J. G. James, courtesy of the U.S. Soil Conservation Service, Department of Agriculture.*)

floods from eroding land may fill culverts and cover highways and even houses with worthless debris. Altogether it seems probable that more than 3 billion tons of the best and most fertile soils are lost from the fields of America each year.

Wind Erosion. Wind erosion has caused grave destruction of soil resources in regions of deficient rainfall. Originally semiarid land had a sufficient cover of grass and other herbage; its soil was held in place, and the wind did negligible damage. When the grass cover is destroyed by either overgrazing or the plow, the land is maladjusted to the natural conditions, and damage by wind erosion occurs. Continued cultivation of the former grasslands breaks down the soil structure and produces a fine dust that permits easy movement by the wind. The finest powdered particles, usually the most fertile part of the soil, may be carried so high and far by strong winds that this material is lost entirely by the afflicted region. The coarser fragments may be rolled and drifted by the wind to form heaps of sand and other relatively infertile deposits that may cover growing crops, adjacent fields, and even buildings.

During the summer of 1934, which was a dry season on the Great Plains, a series of dust storms carried material from these southern plains entirely across the United States and deposited millions of tons of dust, really topsoil from once-productive land, over the northeastern United States. Within the drought-stricken areas from which the dust came, the sun was literally blotted out at midday, and the dust not only was a very unpleasant feature to the afflicted settlers but was severely damaging to human and animal life (Fig. 106). The topsoil of whole fields was sometimes blown away to plow depth, and growing crops were literally blown out of the ground. In the worst cases, farm implements and even buildings were wholly or partly buried under heaps of sand and dust. The experience of these "dry black blizzards" brought home to the entire population of the United States the necessity for the proper control of wind erosion.

Control of Erosion. Protective measures for conservation of soil have been developed by the Soil Conservation Service and various other agencies. For example, contour cultivation and building of terraces on sloping land helps to prevent runoff and will increase the amount of ground water available for plants. If sheet erosion or gullying has removed most of the topsoil, the area is planted to grass and trees that will bind the soil particles together and build up the soil. Planting of grass may suffice to hold the soil and will supply grazing. In the southern states a legume, lespedeza, is very successful in eroded land in stopping erosion and providing fodder. It also builds up the nitrogen content of the soil, thereby helping to fit it for raising crops again. Soil-conservation measures that result in the use of grass and legumes will lead to greater diversification in the cash-crop regions, by encouraging dairying and livestock production. Gullies sloped and planted to grass or trees will stop erosion and lead to rebuilding the depleted land. Sometimes crops are planted in strips along the contour, with hay alternating with cultivated crops at close enough intervals to check any tendency for erosion to carry material down the slope (Fig. 196).

On the public range, in the western states, both the water supply and erosion by water and wind have become a serious problem, brought about by the practice of overgrazing. Stockmen had paid nothing to use publicly owned grassland, and many were in the habit of abusing the natural fodder it provided. Finally Congress created range districts in which the rights to graze are leased by stockmen under the Taylor Grazing Act of 1934, revised in 1936. The number of animals then is reduced so that the grass and other plants have a chance to reseed themselves; ultimately this will lead to an increase in the carrying capacity of the open grasslands, besides preventing much of the damage now done by erosion. Increasing the plant cover

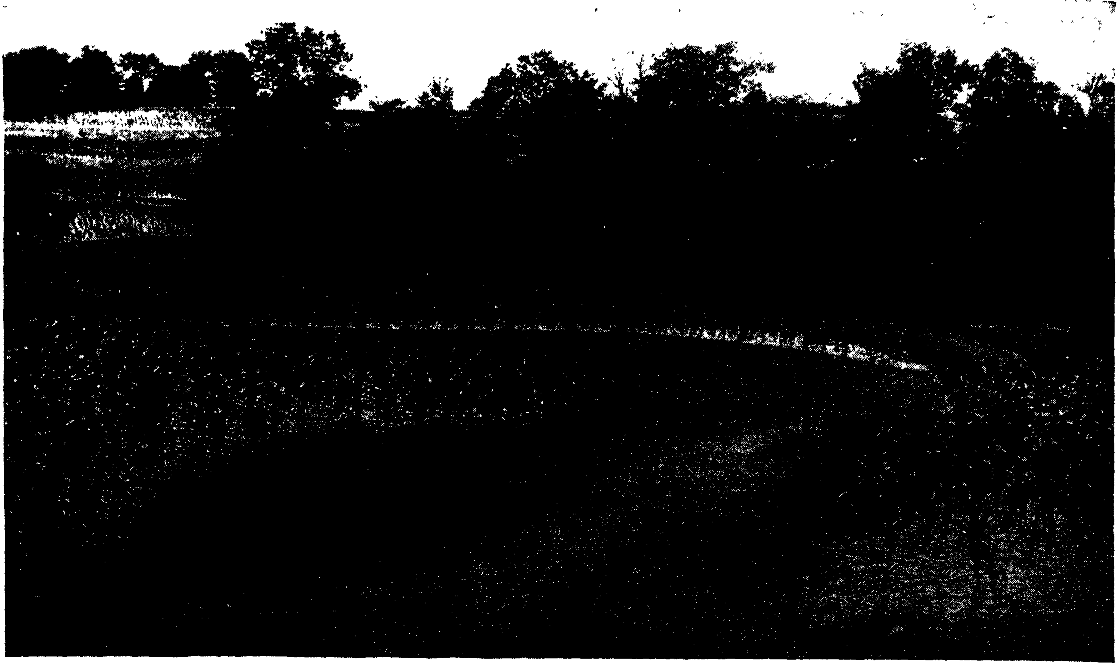

FIG. 196. Strip cropping to control soil erosion is shown in the background with a grass-covered waterway separating strips of planted corn in foreground. Measures to control soil erosion will save this farm from the losses apparent in Fig. 174. (*Photographed in the Muskingum Valley of Ohio. Courtesy of the U.S. Soil Conservation Service, Department of Agriculture.*)

will slow up the runoff and help to replenish the depleted supply of stock water.

Efforts to control the movement of soil by the wind and to reseed injured parts of the Great Plains to grass and other plants that will hold the soil particles and prevent drifting and erosion have been successful. Trees were planted for windbreaks on the plains to lessen the wind velocity, decrease the evaporation of soil moisture, and help prevent soil movement. Although some windbreaks have been successful, it has been concluded that most of the Great Plains is not suited to tree growth and that other control measures should be adopted. Among the methods used to reduce wind erosion are (1) the cultivation of the soil in strips at right angles to the prevailing wind so that surfaces of comparatively narrow width are all that is exposed to wind action (Fig. 197); (2) the addition of straw, manure, and other refuse to the ground to help prevent the wind from getting a start; (3) change in the methods of cultivation of wheat by disking or subsurface tillage rather than plowing the ground; (4) leaving a rough clod mulch and unburned stubble mulch, as in dry farming, instead of forming a dust mulch and burning off all the straw; (5) seeding grain by the furrow method, with stubble residues on the surface, whereby moving sand is deposited in the depressions before any extensive erosion occurs; and (6) reseeding of overgrazed, wind-eroded, and otherwise abandoned land.

Farm-land Situation in the United States. In the United States there are 460 million acres of potentially good crop land, according to H. H. Bennett. Some 80 million to 100 million acres of the 460 million need drainage, irrigation, clearing of woodland, or other labor before it can be used for crops. Of the total arable land in the United States, only 70 million acres of the best land lie level

FIG. 197. Strip farming in Klickitat County, Washington, for control of wind erosion. The darker strips have been plowed in preparation for planting wheat. Lighter strips remain in stubble, cheat grass, and other herbage to restrict movement of soil by wind. In the future, wheat will be seeded on these unplanted strips and those used for wheat will revert to grass. (*Photograph courtesy of the U.S. Soil Conservation Service, Department of Agriculture.*)

enough so that no protection against erosion is required. The control of soil erosion is one of the most pressing problems in our country and must be solved if we expect to maintain our present high living standards. In 1947 it was estimated that 100 million acres of our land was being farmed by recommended methods that will conserve the soil. The use by all the farmers of accepted practices for the prevention of erosion would be highly desirable. Farmers should consider themselves trustees of their land and should endeavor to pass it along to their successors in better condition than that in which they received it.

PROBLEMS

1. What principal soil groups occur in your locality?
2. What are the principal problems of the farmers in your locality with respect to the soil conditions?
3. How may fertile soils become nonproductive?
4. How may depleted soils be restored to fertility? How can their productiveness be maintained?
5. Where has soil erosion occurred in your locality, and how can this be reduced?
6. If available, consult a soil bulletin of the U.S. Bureau of Soils and note how the publication might be used by farmers.
7. What drawbacks have sandy soils for farming? What crops thrive in sandy soils? What advantages have sandy soils for the production of these crops?
8. Prove or disprove the following statement: "Soils in a given type of climate tend to become similar after a long period of time."
9. Defend the following view: From the standpoint of agriculture it would be desirable to prevent all soil erosion.

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Note: Numerous publications of the U.S. Department of Agriculture, as well as those of the Soil Conservation Service, are helpful in the investigation of the geography of soils. Many state experiment stations and extension services of state agricultural colleges also provide useful publications in this field.

CHAPTER 18: *Agriculture*

Agriculture is a basic or paramount activity of civilized man. Hunters, fishermen, and gatherers of the bounty of nature never advance beyond the stage of primitive society; and herders advance little further because their life must be subordinated to the necessities of the animals. Only peoples whose economy is based on farming reach a degree of security and leisure that permits them to advance along cultural lines. Industrialization of nations and the development of large numbers of populous cities have come in modern times, but in the ultimate analysis commerce and industry are largely dependent upon agriculture (Fig. 247). Without the farmer, factory workers and other city dwellers could not be fed, many raw materials like cotton would be lacking, and the principal market for the products of urban industry would be lost. Thus a very close relation exists between the prosperity of cities and that of the rural districts tributary to them; and it is a commonplace to state that cities generally grow in proportion to their hinterlands (that is, the area they serve).

Factors Affecting Agriculture Land. Several natural and human factors influence the utilization of land for agriculture. The soil, rainfall, length of growing season, topographic condition, and location with respect to transportation and markets are among the natural factors affecting agriculture. Labor must be spent on land before crops can be raised, and some land requires much work, if it must be drained, irrigated, or cleared of forest before plowing and planting. Not all land can be tilled—only a low percentage of land in some countries and states is arable, whereas 90 per cent of Belgium or Iowa can be used for crops. Houses, roads, fences, and other works of man may reduce the land that is cultivated. Plants that are available for domestication and improvement, or the types of plants that have been introduced by man, also help determine farm crops and farming systems. Experience, culture, and other human attributes are also factors affecting agricultural practices.

Human Adaptation and Agriculture. Peoples differ in the food they prefer and the methods of farming that they follow. Different peoples in the same environment may exert quite different effects on the land; thus Manchuria has much the same kind of climate as the Dakotas, yet the intensity of cultivation is far different. Whereas the man in Dakota farms hundreds of acres with machinery, his Chinese counterpart in Manchuria farms a few acres with primitive implements. Western France and England are separated only by the narrow English Channel, but the methods of farming, the rural life, and even the appearance of the two landscapes are distinctly different. Systems of agriculture adopted by different peoples vary greatly. By trial and error, man finds those crops which will do best in his local environment, and in general he works out a system of farming reasonably well adapted to conditions.

The density of population in a given area may also determine the type of farming that is undertaken. The Chinese system of agriculture is characterized by intense cultivation of small farms, in some provinces averaging only 1 to 5 acres per farmer. It began in the semiarid Wei Ho Valley, which requires irrigation. From their beginning around Sian over 5,000 years ago, the Chinese have increased to more than 400 million people, who may speak different languages and dialects but nevertheless have the same general system of agriculture and a similar cultural life everywhere in the areas they occupy.

Some people can adapt themselves readily to different environmental conditions; but, generally speaking, farmers have the best chance of success when they emigrate to re-

gions of similar conditions, that is, when they select a new home that has an environment similar to that of the old home. Thus the settlement of New England and the middle colonies by the English was favored because the climate resembled Great Britain sufficiently well so that much the same type of crops could be raised and livestock kept as in England. Italians, with their ability to care for vineyards and the various Mediterranean fruit trees, succeed well in California, where the climate is similar to that in their Mediterranean homes. Italians and Polish people successfully raise produce on market gardens in New York, New Jersey, and the Connecticut Valley on which much hand labor is used. Other examples of good adjustment of immigrant farmers to regions of similar climate include the Finns in northeastern Minnesota; Scandinavians in the northern states from the Great Lakes to Puget Sound, and the Germans who helped make a success of dairying in Wisconsin. The English and Scotch sheepherders and dairymen have transferred their activities successfully to a similar region in New Zealand, and settlers from the British Isles have populated southeastern and southwestern Australia.

Agricultural Patterns. The distribution of land that is used for farming varies widely, depending on factors like relief features, soil, drainage, and local climatic differences. In mountains and eroded plateaus cultivation is restricted to narrow strips and little plots. In parts of the Lake states the glacial deposits, lakes, and swamps cause a very patchy pattern of tilled land. In contrast are the fertile lands of the Mississippi Valley and southern Russia, where for miles the land is all in productive use. In the arid West of our country or in the equally dry Indus Valley in Pakistan, great differences are seen on adjoining plots of land, depending on whether the ground is irrigated or is still untamed desert.

Land included in farms has different uses: tilled crops, orchards, pasture, wood lots, buildings, and lanes. The various uses of the different fields and types of crops raised have marked effects on the landscape, whose appearance changes with the season of the year.

Subsistence Agriculture. Almost all farming operations can be classified into subsistence, cash crops, and diversified-farming systems. Hundreds of millions of people in the world obtain their chief support on self-sufficient farms from which they secure practically everything they wear, eat, or otherwise consume. Although today it is rare to find a farmer, no matter how remote, who does not purchase something he does not produce, the great masses of human beings in China, India, Africa, and the tropical Amazon Valley raise most of the things they need and purchase comparatively little. Corn-raising American Indians before the days of Columbus lived under similar circumstances, as do even yet some of the Pueblo Indians of the Southwest and many natives in Latin America.

In colonial New England, farmers were almost wholly self-sufficient, raising wheat for flour, corn for meal, and buckwheat for hotcakes, all of which grains were ground by a local mill operated by water power. They tapped maple trees for sirup and sugar, or raised sorghum for sweetening. They fattened hogs and cured their own bacon, hams, and salt pork; tanned their own leather, which was made into shoes by itinerant shoemakers; and cut their own fuel. Local mills sawed their trees into lumber for houses and barns. A prosperous farmer might have an actual cash income of only \$20 or \$30 per year, yet he needed to buy almost nothing. The women carded wool, spun the yarn, and wove homegrown flax and wool into clothing for the entire family. Stockings, mittens, caps, sweaters, and other garments were made from the wool. Furs of animals were utilized also. Food, clothing, fuel, and shelter all came from a few acres of New England hillside.

Today the same New England farms that once produced a surprising variety of goods may grow only hay and a little fruit, with fresh milk and cream the chief source of income on most farms, helped in some places by the sale of apples and poultry products or

by the income derived from tourists. Even much of the corn, bran, and other concentrated feed for the cattle and chickens is imported. The tendency on most farms in the United States today is to specialize on one or more cash crops, with the result that farmers are more affected by variations of prices and other results of modern industry than in the "good old days."

Hundreds of millions of peasant farmers in Asia and Africa practice subsistence agriculture and are often forced to continue in that practice by poor transportation and other handicaps, though custom is a factor in continuing the practice. Handling tiny plots of ground by primitive farming methods (Fig. 66), the peasant by steady application is able to raise barely enough food to maintain himself and his family. Clothing is homemade, and there is little variety in food. Because these farmers sell little, they can buy almost nothing, and this leads to a low standard of living and prohibits the ordinary comforts that American families enjoy.

Intensive versus Extensive Agriculture. In general, agriculture can be classified as intensive or extensive. In the United States intensive farming is characteristic of the market gardens near large cities, the truck and small fruit farms of the southern states which supply the northern market in winter and early spring, much irrigated land in the arid West, and fruit orchards nearly everywhere. In densely populated lands nearly all the agriculture is intensive (Fig. 92) because there is an abundance of cheap efficient labor available. Intensive agriculture requires much human labor devoted to a small plot of ground so that the land will produce the greatest possible amount of food. Such expenditure of labor is possible in the United States only when high-priced crops like tobacco and fruits are produced; but in China, India, and Java where the press of population on the land is very great and a surplus of labor exists, the human energy expended is no longer a consideration and most crops are grown by intensive methods. Where land is hilly and fields are small, or there is a demand for specialty crops like fruit and vegetables that take much human labor, intensive agricultural methods are found. Belgium grows nearly twice as much wheat per acre as does the United States; but this result is attained only by great expenditure of human energy, and expense per bushel for producing the grain is higher than for producing that raised by machinery in the United States.

In extensive agriculture (Fig. 105), the problem of the farmer is to produce the greatest amount of food per unit of man power rather than per unit of land area. This may lead to somewhat careless methods of farming, and the yield per acre will be less than where land is intensively farmed; but, by the use of power equipment, crops can be produced so cheaply that the cost of a food product may actually be less in a land of high wages where machinery is used than in a land of low wages where hand methods prevail. Thus rice is grown in California, Texas, Louisiana, and Arkansas at less cost per bushel than in China or Japan, yet wages in America are many times those paid in the Orient. Extensive agriculture can not be carried on in all locations. It is best adapted to open plains or gently rolling topography, lacking in dense populations.

Sometimes the system of land ownership has a material effect upon land utilization. For example, the wheat section of Argentina has a crescent shape inland from Buenos Aires, and most of the land within a hundred miles of Buenos Aires is in stock farms rather than in grain farms, although the soil and climate are usually favorable for wheat and corn. The explanation is partly poor drainage and greater frequency of rain at harvest than farther west, but another factor is that this land is held in very large estates. The owners can secure all the income they can spend with less risk by producing beef cattle, mutton, and wool than by growing grain, and they are therefore little interested in buying machinery, plowing the land, and producing money crops for sale.

Agricultural Specialization. Although specializing upon the production of one crop leads to higher standards of living, the practice is dangerous and may lead to failure if anything happens to the specialty product. Most of the crops of the United States entering trade are raised by one-crop farmers. Thus we have the cotton farmer in the South, the wheat farmer of the Great Plains, the apple grower of the Northwest, and the fruit ranch producer of California and Florida; even the cattleman or sheepman is likely to specialize on one type of animal. In favor of one-crop specialization is the fact that different soils and climates are best adapted to certain plants, and that, by raising a product exclusively in the place in which it is ideally adapted, better quality and quantity can be produced by the skills developed by the specialist farmer. A long distance to market, however, may cut down the net returns to the producer. Reliance upon one crop is somewhat undesirable, since adverse climatic conditions and harmful insect pests and diseases may destroy the single crop. War panic or overproduction may prevent the profitable marketing of one particular product. Reasonable diversification certainly offers less risk than single-crop production.

Diversified Farming. Diversified farming is a common characteristic of the central United States and western Europe. It is less exhausting to the soil, since different crops remove different proportions of the elements from the soil. Then too, under diversified farming methods, dairy cattle, pigs, poultry, and other animals are kept, and much of the hay and grain raised on a farm is consumed by the animals. Their manure goes back to enrich the farm, and the farmer gets most of his income from the sale of beef cattle, hogs, calves, wool, lambs, milk, eggs, and poultry. Significant features of this type of farming are also (1) growing of legumes or other soil-building crops and (2) well-developed crop-rotation systems. The clover and other fodder crops are fed to livestock, and the soil fertility is maintained by the green-manure crops in addition to the animal product. If a farmer practicing mixed farming raises grain for sale, it is probably a side issue; and a failure of the grain crop or an apple crop or any other single crop that he plants will not be a complete economic loss. In recent years in our Middle West there has been a large expansion in the growing of soybeans, which have proved a good crop for rotation with others in this region. The proprietor of a farm where large numbers of animals are kept is tied down much closer to his home than is the producer of a single crop. A cotton grower or a wheat grower of the Great Plains may work only a hundred days each year to get his farm work done. It may not be profitable when he sells it, but he actually works in raising the produce only from one-third to one-fourth of a year's time, while the farmers using diversified agriculture are busy at some task at least part of every day in the year.

Plantation Agriculture. In contrast with diversified agriculture, one-crop farming may be carried to extremes and placed on a scale that resembles factory production. The natural tendencies of man are to provide food for his own needs and for those of his immediate family, tribe, or clan. This involves relatively small planted areas, no larger than an individual and his relatives can work comfortably. Some parts of the world, however, lend themselves to extensive rather than intensive cultivation; this is particularly true of tropical and subtropical lands, whose trees are so large and numerous that cooperative human effort must be expended in order to develop a tract of farming land. Such effort, under a system of cooperation or operation dictated by necessity, leads to landholdings of excessive size, far too large for the individual to work alone; intricate financing; the use of special types of implements for cultivation; and an elaborate and expensive system of transport for sending commodities to market. It also requires a labor force that may mount to thousands of men.

Thus the plantation system as an economic enterprise is especially well developed in trop-

ical regions, producing marketable surpluses of foods or other goods—most of which are shipped to mid-latitude consuming centers as luxury or specialty commodities: bananas, coconuts, cane sugar, pepper, pineapples, cloves, tobacco, tea, coffee, chocolate, rubber, cotton, and abacá, as well as many others less well known in this country. For the most part, the great plantation crops have come on world markets in recent times, though tea, pepper, cloves, and a few others have been important articles of trade for centuries. The more perishable items, such as pineapples and bananas, could not be shipped satisfactorily; rubber entered world trade in quantity only after the invention of the automobile. Chocolate and cane sugar, used in small quantities by the wealthy a century ago, have become household staples in lands that enjoy high purchasing power and whose people can enjoy them.

Large plantation areas of the Malay Peninsula, Sumatra, and other East Indian islands are given over to rubber production; abacá plantations are located in the southern Philippines. Hawaii grows both cane sugar and pineapples on the plantation system (Fig. 198), and two-thirds of the world's chocolate comes from West Africa and tropical America. Tobacco and cotton plantations are common in our subtropical southeastern states; and cotton is also grown in quantities in monsoon India, Brazil, and Egypt partly by the same system. Coconut plantations fringe the shores of South Pacific islands; and the coffee plantations of Latin America and tea plantations of Ceylon, India, China, and Japan are famous.

The development of the plantation system in the humid tropics has resulted in widespread shifts of producing areas, as world-wide demand increased and the original producing area was found inadequate to meet the demand. Thus rubber, originally a native of the western hemisphere, shifted from northern Brazil to southeastern Asia, where a dependable and adequate labor supply was available.

FIG. 198. Pineapples under cultivation in an Hawaiian field. The rich soils formed from decomposed lavas support this fine commercial crop. Weeds are prevented from growing between rows of pineapple plants by means of paper strips fastened to the ground. (*Photograph used by permission of the Hawaii Visitors Bureau.*)

The cacao plant, source of our chocolate, cocoa, and cocoa butter, changed its principal plantation area from the Andean countries of northwestern South America to Nigeria, the Gold Coast, and other West African centers. Coffee, a plant believed to have originated in Arabia, is now grown as a plantation crop in the Western Hemisphere in Central and South American highlands. Many other producing areas have been radically changed as the world has come to know and appreciate those contributions which the tropical plantations could make to its comfort and pleasure.

Staffs of Life. Most peoples of the world prefer a particular grain or starchy foodstuff for their "staff of life." Some of these foods are grown extensively in certain areas and shipped to distant markets; others are consumed almost entirely by the community where the crop is raised.

The density of population and requirements for food crops affect the amount of arable land that is planted to crops. In parts of the Ganges delta in the province of Bengal, now divided between India and Pakistan, more than 1,000 people per square mile derive their support directly from the land, and every bit of soil is cultivated. Similar conditions are found in China and Japan. In contrast, New Zealand, with fertile soil and a favorable climate but less than two million inhabitants in an area double the size of New York State, uses only 3 per cent of its area for crops and keeps most of its arable land in permanent pasture.

The climate is an important factor in determining the kinds of crops that are raised. Examples include the farms of New England whose cleared land is largely in hay and pasture; the Great Plains, where half the land in a single county may be planted to wheat; a Wyoming ranch, with 99 per cent pasture and 1 per cent hay; and the intensively used irrigated land near Los Angeles, devoted to fruit and truck crops. Farming as related to conditions in the different climatic regions has been discussed also in the appropriate preceding chapters.

Farms and ranches include about 55 per cent of the total area of the United States. The balance is mountains, forests, deserts, swamps, and parks or is used for nonagricultural purposes like roads and towns. Only 17 per cent of the total area of our country is in crops; this is less than one-third the acreage of the farms and ranches. Two acres are in pasture and wood lots to every one in crops. If a demand comes in the future for more food crops, the acreage under cultivation could be increased by at least one-half, although the expense of farming this additional acreage would probably exceed present average costs, since the best and most easily tilled land is naturally developed before inferior types are used. With the passing of time, changes in farm systems and increase in population bring changes in the agricultural pattern. Thus an Ohio farm might be used first for sustenance, then for cash wheat, and now for diversified farming.

Grains. *Wheat* enters into international trade to a greater extent than do other grains. More than a billion bushels of wheat are involved in this foreign trade, out of a total world wheat crop amounting to 5½ to 6 billion bushels annually. The bulk of the export wheat comes from the United States, Canada, Argentina, Australia, and the U.S.S.R., with Hungary, Rumania, Manchuria, and North Africa usually having some surplus for sale. France, Italy, Germany, Poland, China, India, the Balkans, and the Near East grow large amounts of wheat but can seldom spare the grain for export. Even England grows some wheat, although it is the largest importer of the grain among the nations. Other countries in southern, western, and northern Europe are important buyers of wheat, and some is sent to tropical countries where it cannot be raised. In western and southern Europe, China, India, and the eastern United States, wheat is raised on small to moderately sized farms, usually in rotation with other crops. In the important exporting

regions, wheat is raised on large farms of several hundred acres up to thousands of acres in size, which are often completely mechanized. The areas now used for cash wheat production were formerly mainly semiarid grasslands. In North America the wheat belt covers much of the Great Plains and extends from northern Texas northward to beyond Edmonton, Canada. The black-soil belt in the U.S.S.R. extends eastward from the southern Ukraine into Siberia and is one of the great wheat regions of the world, much of the grain coming from large communal farms.

Rice is typically grown in the monsoon regions of eastern and southeastern Asia, with small amounts harvested in other tropical and warm temperate regions. China, India, Japan, Java, and the Philippines are large producers and consumers of rice. Burma, Siam, and Indo-China are the most important exporters of rice. In the United States rice is grown chiefly in California, Texas, Louisiana, and Arkansas. Sections of Brazil, northern Argentina, Egypt, Spain, and Italy grow some rice for local consumption. Nearly half of the world's people call rice their staff of life, and the quantity of rice grown exceeds that of wheat. Most of this huge crop is raised by hand methods and is consumed by the people who plant it. Only in the United States are machine methods used in planting and harvesting rice.

Corn, or maize, was a native of the New World but has been carried from the Americas to Africa, Europe, and Asia, where it is becoming of increasing importance. The world crop totals about 5 billion bushels, somewhat under that of both wheat and rice. Of this total the United States grows about three-fifths. Corn is used for food by many people, but the largest share of the crop is fed to livestock (Fig. 199). Some corn is processed and sold as sirup, starch, and other products. The United States is not a large exporter of corn but does export pork products after the pigs have been fattened on the grain. Argentina grows less corn than the United States but ships more corn to Europe than does our

FIG. 199. Corn Belt farm in Iowa, with evidence of prosperous farming. Domestic water is obtained from shallow wells operated by windmills. Barns are large enough to hold herds of cattle during the winter and to provide storage for hay and grain; silage is stored in the silo at end of barn. This farm is well provided with outbuildings for shelter of machinery, and the dwelling is large and modern. (*Photograph courtesy of the U.S. Department of Agriculture.*)

country. Hungary, northern China, Africa, Mexico, and Middle and South America are among the producers of corn. Corn thrives best in a humid climate with warm summers. Cold limits the northward limit of the Corn Belt in the central Mississippi Valley; dryness governs the westward limit.

Minor grains cultivated by man are numerous. Oats, used mostly for livestock, are grown in the mid-latitudes. Rye is a hardy grain and is planted in poor soils and along the outer climatic limits of wheat, which it will generally outyield under unfavorable conditions. Some barley is grown as a spring-planted crop in the northern mid-latitudes, but it is also grown as a winter crop in regions with a Mediterranean climate. Barley finds use as a food for both men and animals. Millet and the grain sorghums are used as a cheap food by man in regions where rice and wheat are too expensive for poor people, as in Africa, northern China, and India; but in the United States these grains are grown almost entirely for stock feed.

Soybeans are a valuable food, a source of oil, a stock feed, and a raw material for industry. Formerly soybeans were imported from Manchuria and other parts of China, but now they are widely grown in the central United States.

Starchy Foods. *Tubers and roots* of many plants provide needed starch for man's diet. The white potato was native to the highlands of South America but was carried to Europe and has become a most important food in that continent, where it thrives in the cool rainy regions. An acre planted to potatoes will supply more food than an equal area of most other crops, and it is therefore a useful crop to grow in thickly populated areas with suitable climate. The U.S.S.R., Germany, and the United States are leading producers; but nearly all European countries grow potatoes, and they have been introduced into northern China. In Europe potatoes are used for stock feed, beer, industrial alcohol, and starch, but they have not been used along these lines much in the United States. Sweet potatoes are grown in quantity in the southern states and throughout the tropics. They are valuable for stock feed as well as a useful food for man.

The roots of the manioc, or tapioca plant, are extensively grown in rainy tropical regions. Taro, arrowroot, and the pithy trunk of the sago palm in the Netherlands Indies and some varieties of tree ferns in the Pacific Islands have been used as foods.

Fruits that contain much starch and are widely used for foods include many varieties of the banana. In the Congo Basin and the Amazon Valley it is the most important food for some native tribes, and it supplements rice and other foods in many other tropical localities. The lands tributary to the Caribbean Sea raise bananas by the plantation system and export them by the shipload to the United States.

In the South Pacific islands the breadfruit has been widely used as a main source of starch in the native diet.

Livestock, Dairying, and Small Animals. When using plants he has sown, cultivated, and harvested, man goes directly to the land for his food and shelter needs. This type of existence, of course, is strictly vegetarian. If, however, for the sake of variety or for other reasons he uses the products of animal life, he concentrates on the feeding and care of animals, thus using plants indirectly for his own food. In general, reliance solely upon plant life will allow the earth to support more people than when the plants are fed to livestock, which in turn are used for food. For the most populous parts of the world, meat is a luxury food for the great masses of people, but in more sparsely populated semiarid lands, it is feasible to raise livestock on a large scale where natural conditions are unfavorable for most farming. Furthermore high standards of living and good purchasing power make it possible for urban people in some lands to enjoy the products of the dairy; this creates a commercial demand for cheese, butter, and the like, and stimulates the production of animals for dairy purposes.

In many respects the human occupation of

grazing is the same throughout the world, whether the emphasis is placed upon cattle or upon sheep. In either case, it is possible to use extensive ranges or stall feeding and small pastures; if on large ranches, the cattleman or sheepherder tends to lead a seminomadic life, dependent upon the location of good forage for his animals. In either case, isolation is usually his lot for long periods, and he must rely on his dog and horse for companionship. Thus the cowboy, *vaquero,* or *Gaucho,* experiences a type of life that is unfamiliar to those who carry on a more sedentary existence. Similarly, the sheepherder, whether he tends his flocks on the slopes of Palestinian hills, among the Owyhee uplands of Idaho, in the Kittitas Valley of Washington, or in more remote parts of the world, leads a seminomadic life in search of water and feed for his charges. The ancestors of the Boers in South Africa came from the rainy fertile Netherlands, where intensive farming and dairying were customary, but in the semiarid *veld* (grasslands) of their new home these people adapted themselves to quite a different environment. The Boers became stockmen, each occupying a large tract of land and doing things in an extensive way.

In arid and semiarid climatic regions there may be sufficient precipitation for grasses that can be used for animal feeding but insufficient moisture to carry on actual cultivation of the land with any marked success. These borderline semiarid sections are of considerable extent and occupy large parts of western North America, central Asia, and southern South America in the middle latitudes, as well as interior parts of Australia, South Africa, North Africa, and northern South America in the lower latitudes. Generally stock-raising activities, leading to the production of supplies of meat and hides, are on a very extensive scale. The same is true of sheep raising, which provides both wool and meat.

Cattle. The greatest cattle-producing country is India; but for a number of reasons these cattle contribute little food or hides to the flow of world trade, and economically India's cattle are of little importance. The United States and the Soviet Union are equally large cattle raisers, with Brazil, Argentina, China, and Australia following approximately in that order (Fig. 200). In semiarid regions there is a close relationship among the numbers of cattle, the quality of the forage, and the expanse of land that is used for grazing. If the grass is poor or the cattle are too numerous for the "carrying capacity" of the range, the quality of the final product is bound to be inferior, the valuable supply of good grass is destroyed or diminished, erosion sets in, and the range declines in productivity. This must be guarded against, particularly where cattle are grown extensively on a commercial basis, as on the Great Plains or the Pampas. Cattle production by family or tribal units on a noncommercial basis in central Africa is less likely to bring unsatisfactory results unless outright abuse of the natural grazing resources is prevalent.

One of the requirements for successful livestock ranching is that the range shall be of large extent. This involves fencing or some other method of keeping the cattle under control, annual gatherings for branding or slaughtering, widely spaced ranch settlements, and specially trained men who are familiar with the aspects of cattle ranching. Great progress in livestock ranching has been associated with improvement in cattle breeding and the elimination of insect pests. Many parts of Africa today could produce more cattle if it were not for the ravages of a cattle pest, the tsetse fly. Gradually most of the serious cattle pests and diseases have come under control. Animal breeding can be carried on successfully with definite objectives—breeding for larger or richer supplies of milk; heavier weight and more meat; more tender meat, and the like. Improvement in animal stocks promises to be more widespread with the recent advances in artificial insemination.

Principal demands for supplies of meat come from northwestern Europe, which is unable to provide enough meat for its mil-

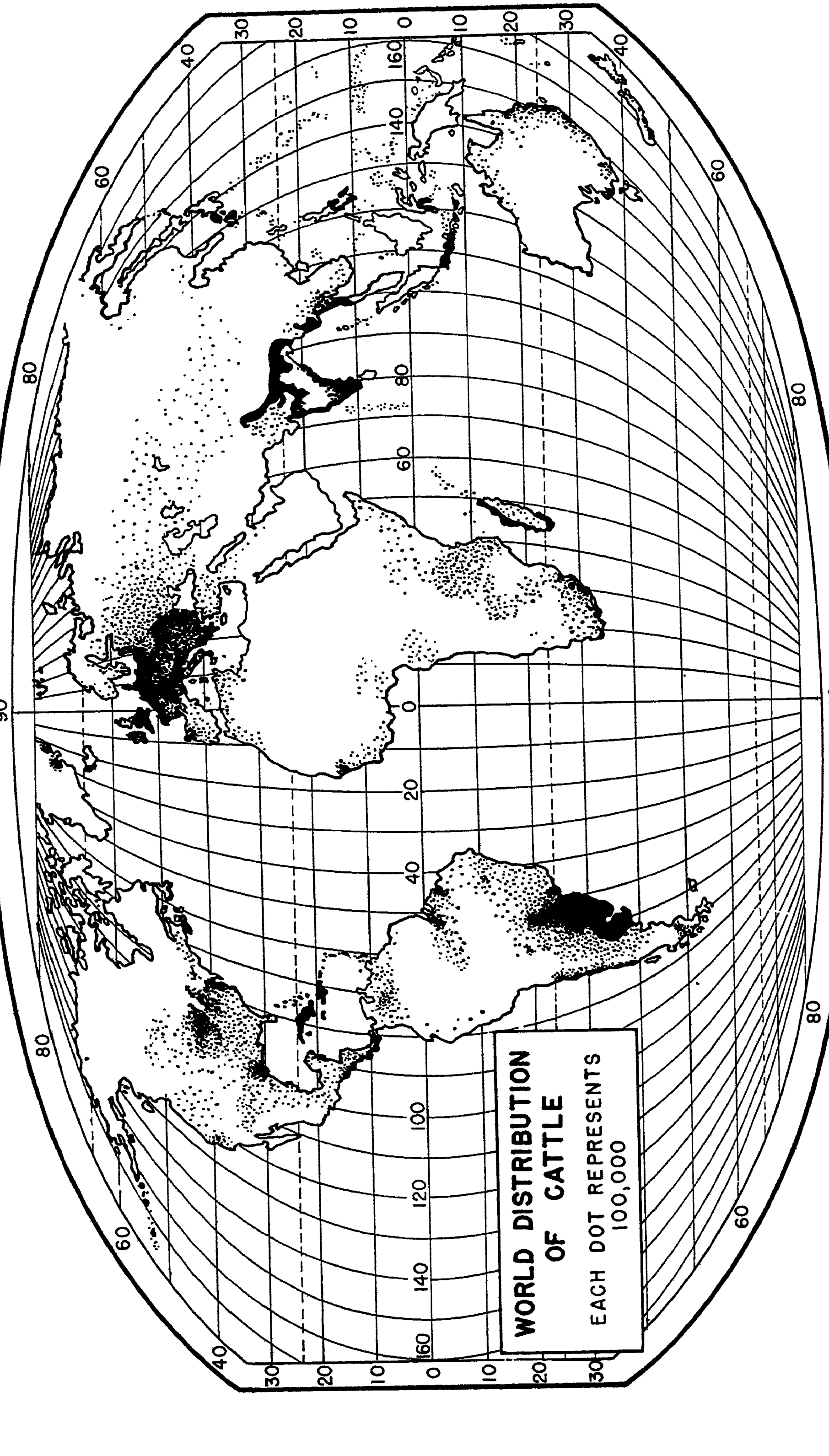

Fig. 200. World distribution of cattle.

lions of people. England especially is a large importer of beef products, as well as Germany, Sweden, and France. Mediterranean Europe uses relatively small amounts of beef. The principal exporter of beef and beef products is Argentina, followed by Australia and New Zealand, and Brazil, but Argentina is far ahead of the other nations in this trade. For its size Ireland is important for exports of beef cattle which come mainly from farms smaller than those which are located in less rainy regions. English farms and those in our own Middle West also make significant contributions to the meat supply.

Dairying. In contrast to the extensive type of activity involved in the production of range cattle for beef and hides, the dairy industry usually requires much smaller space in which to operate and thus is found in the more humid parts of the mid-latitude regions, in close proximity to large urban centers that rely upon its milk and cheese for part of their food supply. The notable exception is New Zealand, whose butter and other dairy products have found a world market despite her distance from large consuming markets. This was accomplished by the invention of processes for preserving the quality of milk through canning, dehydrating, and rapid shipment under mechanical refrigeration. Denmark and the Netherlands both specialize on dairy products, the former on butter and the latter on cheese. Both find ready markets in neighboring nations.

Dairying as a human occupation may call for the stall feeding of cows if the project is located in regions of severe winter, as in the northeastern United States. This involves the cutting, drying, and storage of hay or other feed in amounts sufficient to carry the dairy herd through the winter, and it may add considerably to the costs of production. Extreme care must be taken to ensure the cleanliness of the product. Rapid transit and other considerations make dairying a highly specialized and advanced form of human economy—and a highly profitable one if geographical conditions are right.

Sheep, like cows, are multiple-purpose animals and of widespread distribution, though the New World did not know them before the conquests of the Spaniards. At present they are raised in the greatest numbers in the Soviet Union and in Australia and New Zealand. In the Soviet Union they are needed for food and clothing by the Russians and the many natives of central Asia; in Australia and New Zealand they are grown far in excess of local needs and are shipped for food and fiber to northwestern Europe, especially to Great Britain to augment the British sheep production. In the western United States sheep are raised mostly by the ranching method, but in the northeastern part of our country they are commonly kept in fenced pastures, as in the hills of southern Ohio. Other principal producing areas include India, China, the Union of South Africa, and Argentina. Sheep are grown successfully throughout middle latitudes where they withstand cold winters, as well as in the dry climates where they can utilize grasslands too meager for larger animals. They also grow well in the high altitudes of the tropics, along with other wool- and hair-bearing animals such as the alpaca and llama of South America's highland areas.

Goats, to a greater extent than sheep, can utilize poor forage, and in general they constitute a more highly domesticated animal. They need not range so widely as sheep or cows in search of water, and thus they lend themselves well to domestic production among such sedentary peoples as the oasis dwellers of Arabia or the Sahara. They do not provide a good meat supply but are highly regarded for the quality of their milk. They are most common in India, the Union of South Africa, Turkey, China, Spain, Greece, and Mexico—in general, in lower latitudes than either sheep or cattle. They are usually indicative of low standards of living, but some highly valued types of hair are obtained from them.

Swine are sometimes scavengers, relying on almost any form of food they can find, but in other situations may be carefully bred, fed,

and cared for. Although pigs in some parts of the world are given little attention, in the Middle West of our country they are of selected stock and are generally fattened on corn. Here pigs are not allowed to range far from the home pen and are used as little manufacturing plants to turn grain and various foods that might otherwise be wasted into excellent meat. For the amount it eats a pig puts on more weight than perhaps any other animal. The ease with which pork products are cured is an advantage in the disposal of the meat. Swine are found in greatest numbers in China, the United States, the Soviet Union, Germany, and Brazil. In northwestern Europe and in the United States the pig has become the basis for a large commercial meat industry, and it contributes both quantity and variety of meat to our tables. In other parts of the world, the pig is not commercialized and merely forms one element in the humble economy of the peasant farmer. Among Moslems, Hindus, and Jews, religious beliefs prevent the use of pork.

Tree Crops. There is a human tendency to regard cultivation of the land, with its attendant emphasis on grains, small fruits, tubers, and the like, as the most important use of the land. This may be true in locations where soil depth and fertility, climate, and relief of the land unite to provide a highly satisfactory combination of natural factors leading to agriculture. On the other hand, if soils are markedly infertile or hill slopes are too steep for successful cultivation, it may be more profitable to refrain from destruction of the forest cover, retaining and improving the native stands of trees. Many trees, such as the chestnut, sugar maple, and cherry, are dual-purpose trees; they provide food for man or animals and at the same time are valuable sources of timber. When properly handled, groves of trees may contribute more wealth to their owners than if the land were cleared and sown or planted. Tree plantations of teak in Burma, Christmas trees in Michigan, "sugar bush" in Ohio or Vermont, rubber in the Straits Settlements, olives in Italy, lemon groves in Sicily, or orange groves in southern California make important contributions to the world's store of products.

The principal disadvantage in "farming" trees lies in the fact that they are slow to mature and bear and that the monetary return on these investments is thus greatly delayed. In a cork-oak grove, for example, there may be no profit whatever for more than a generation of ownership. This delay in return on the investment frequently deters landowners from devoting their efforts to "tree farming" and tempts them to clear and plow the slopes to the permanent detriment of the land use in their neighborhood, causing the silting of streams, erosion of slopes, decrease of soil fertility, and other unfortunate accompaniments of maladjusted land use.

Tendency of Nations toward Self-sufficiency. Some nations from the standpoint of national defense feel that it is desirable to become as nearly self-sufficient as possible. If high protective tariffs, bonuses, import quotas, and other schemes are used, crops may be raised in places that would be unprofitable without such aids. Thus several European countries produce their own sugar from beets at higher cost than they could buy cane sugar from the tropics. In time of war the land would have its own supply, and in time of peace the money that would be spent for the imported sweet is retained at home. In the same way Germany and Italy before the Second World War endeavored to increase food crops with considerable success; thus their imports were lessened, and these countries became more self-sufficient. The schemes that cut down normal imports of farm crops may help domestic producers, but they injure other lands by loss of markets for crops where natural conditions are unusually favorable for cheap production.

Some Types of Farming in the United States. Numerous types of farming are found in the United States (Fig. 201), each with its characteristic effect on the landscape. Thus in the northeastern United States the farms are devoted either to dairying or to specialty

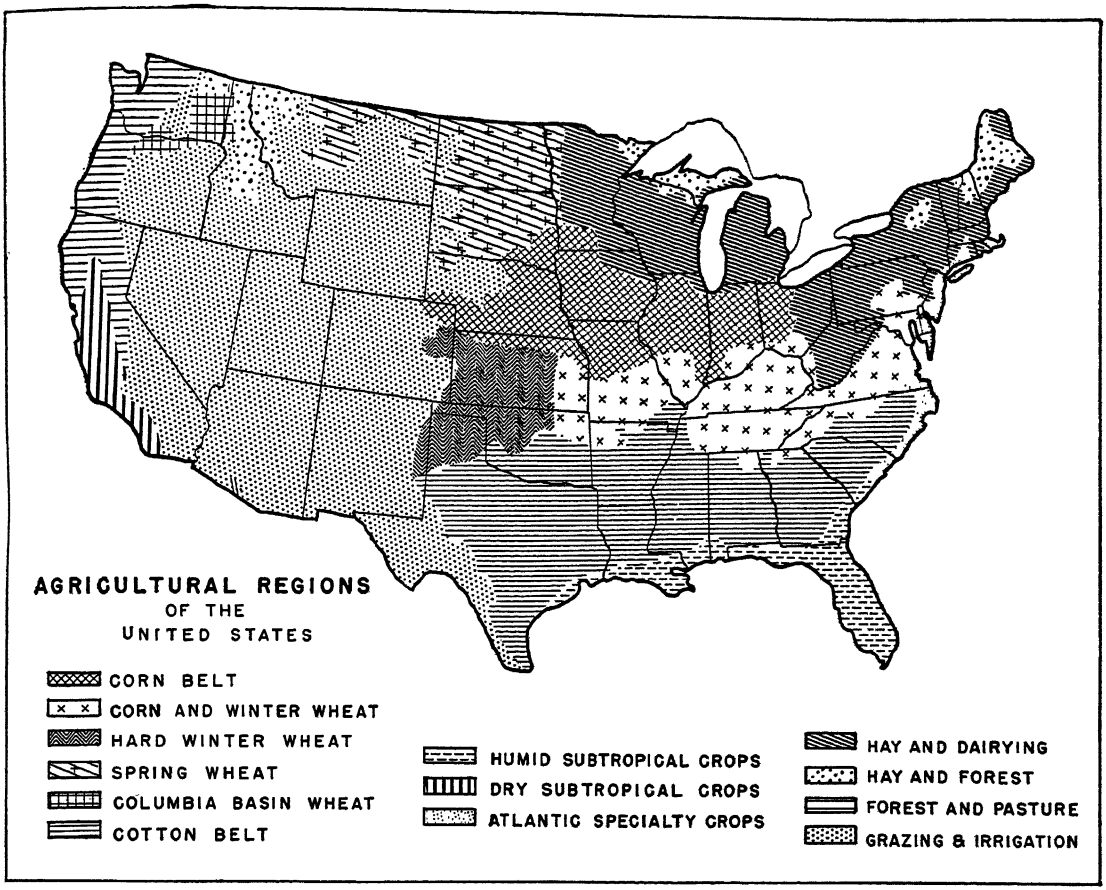

FIG. 201. Agricultural regions of the United States.

crops like potatoes in Aroostook County, Maine, or tobacco and onions in the Connecticut Valley (Fig. 95). The dairy farms, with their large barns for storing hay during the snowy winter and provision for quarters for the livestock, continue through New York, Indiana, Michigan, and Wisconsin. In the extreme South the money crop consists of cotton, raised generally by tenants, both white and colored, living in poor shacks with little livestock or equipment and handling from 10 to 20 acres of land. The amount of land planted to cotton is chiefly dependent on the number of "hands" available in a family for picking the crop. Interspersed through the Cotton Belt are rice farms in Arkansas, Texas, and Louisiana where conditions favor the crop; sugar cane in Louisiana and Florida; citrus orchards in central Florida; and truck gardens to supply the northern markets with vegetables and berries in winter and spring.

The farms of the Middle Atlantic states west to the Corn Belt in areas of fertile soil are generally characterized by prosperous houses, red barns, and numerous outbuildings to accommodate the livestock and machinery (Fig. 109). Farms average from 60 to more than 100 acres in size. They have pasture land; fields devoted to grain and other crops for 2 or 3 years and then planted to clover, which replenishes the soil; hay land, and wood lots. Milk, animals, wool, poultry, and some grain and fruit are all sold from these farms. A Corn Belt farm is generally a sort of manufacturing establishment to turn the corn and other fodder into products for sale, with the

animal or green manure used to maintain soil fertility.

In the southern highlands the system of farming is of a subsistence type, with corn and other food crops raised on hilly ground that is subject to erosion. Resulting crop yields are so poor as to permit only a low standard of existence. In some sections patches of tobacco are raised as a money crop, since it is valuable enough to stand transportation costs.

On the eastern section of the Great Plains the summer rainfall and the growing season favor winter wheat in the central area and spring wheat in the northern portion. Here the farms are a half section to a section (640 acres) in size; and, where the rainfall becomes less than 20 inches annually, land is left in summer fallow once every third year. Sometimes this is done every other year so that the farmer has only one-half to one-third of his land under cultivation each year. Some wheat farms have no livestock whatever but are entirely mechanized. Under these conditions, the house is the most prominent building. Farmers can attain a more secure existence by practicing diversification and the production of livestock as a side line, rather than gambling on wheat year after year.

The drier and rougher sections of the Great Plains, Rocky Mountain, and Plateau areas are devoted to sheep and cattle ranches. Here the carrying capacity of the land is low, and 40 acres or more of land may be required to furnish fodder for one steer. Under these circumstances, ranches may average from five to ten or twenty thousand acres in extent, with occasional places as large as 100,000 acres or more. Many of the ranches have access to the public range land or national forests, on which grazing rights may be leased. In the grazing country not only are the ranches far apart, but the trading centers are also widely scattered, sometimes with intervals of 50 or 100 miles between towns, yet these centers seldom support more than a few hundred people.

Where irrigation may be practiced and a growing season of 150 days or more prevails, intensive agricultural development by irrigation has occurred. Often different sections have specialized on certain crops, although alfalfa is grown almost everywhere. Near Salt Lake City, in the Yakima and Wenatchee valleys of Washington, and the Hood River Valley in Oregon, apples, cherries, peaches, pears, and other fruits are important (Fig. 202). The Snake River Valley in Idaho, the Yakima and Moses Lake areas in Washington, and the delta region in California grow many potatoes. Sugar beets are a specialty of Utah and southern Idaho, as are hops in the Yakima and Willamette valleys. The average apple orchard in the Wenatchee Valley is 15 acres in size. The owners live as near together as suburban residents and are served with running water, electricity, gas, and other facilities as though they lived in a city. Oranges, grapes, and other fruits in California are generally raised under similar conditions. These areas are very pleasant places; but, where a grower specializes only on one crop, he has no other farm product on which he can depend when anything happens to prices or the yield. Diversification for the fruit grower so that there shall be some income or at least sustenance from an acre or two, with a cow and poultry kept as a side line, appears to be the solution to some of the difficulties of the western fruit "rancher."

In some years many growers in the Northwest pay more to the railroads for transporting their apples to market than the producers received as their share, from which they have to pay for boxes, tree pruning, irrigation, spraying, picking, cultivation, and packing of the crop, as well as taxes and interest on farm mortgages. Then may follow several years of bumper crops and top prices. It is clear that farm income must be averaged over a 10-year term or more to determine whether operations are profitable. In California some owners of fruit ranches have retired from other businesses and look upon their places more as pleasant homes in which to live than as income producers, but the man who is always dependent upon his fruit for his income is

that enable the country to keep 30 million sheep and over 4 million cattle in an area only as large as the state of Oregon.

Another limiting factor for crops may be pests or contagious diseases. Thus the coffee blight has nearly wiped out coffee production in Ceylon; the witches'-broom disease has gravely injured the cacao plantations in Ecuador, and the Panama disease has reduced the banana output from Costa Rica. When controls for a disease are discovered, the added expenses increase costs of production.

Government Aid to Agriculture. Many trained men, under both private and government auspices, are devoting their entire time to studying plants, soils, domestic animals, and the control of pests and diseases. They experiment in order to find what crops are best adapted to a region; to develop new and better varieties; and to discover how to handle, improve, and conserve land. Their work helps farmers to increase production, reduce costs, and sell better products. Nearly every state has one or more Agricultural Experiment Stations, and our national government likewise maintains numerous experimental farms. Plant explorers are sent out over the whole earth to find promising new plants and varieties to introduce into this country. Plant breeders have developed new types of grains and fruits that are great improvements over the original stock. Thus wheats have been bred that resist drought, rust, winterkilling, or Hessian fly; that have increased gluten content for flour; or that outyield others. By crossing certain berries the new loganberry and youngberry were secured.

Strict quarantine measures limit spread of livestock diseases like foot-and-mouth diseases, Texas cattle fever, Bang's disease, and bovine tuberculosis. Plants brought into the country are carefully examined to determine if they are free of parasites and disease. When pests have been introduced or native species become damaging, the insects are studied, and poisons or other control measures recommended. Sometimes parasites can be introduced that will feed upon and largely destroy harmful plant pests. In case of a bad infestation, temporary quarantines may be placed to prohibit shipment of infected fruit so as to prevent the spread of the trouble. Thus the Mediterranean fruit fly was introduced into Florida; but, by quarantine and destruction of infested fruit, it has apparently been exterminated. Studies are made of desirable crop rotations, systems of farming that will reduce erosion, methods of marketing that prevent losses in transit; proper fertilizers for particular soils, and many other subjects to aid the success and expansion of agriculture.

Various modern inventions have also greatly aided the expansion and development of agriculture. Among these are laborsaving tillage and harvesting machinery, means of rapid transportation by steam and gas engines, artificial refrigeration, and processing that preserves and condenses foods.

Problems

1. Why does New York State sell fresh milk, while Wisconsin specializes on the production of cheese?
2. In the United States, meat consumption per capita averages 145 pounds per year; in Japan it averages only 8 pounds. What is the explanation for this difference?
3. What is the principal difference between hog feeding in North America and in Europe? Does geography account for this difference?
4. Extensive commercial grazing lands are located in the Southern Hemisphere. What is the explanation for this?
5. Under what geographical conditions will farmers tend to produce dairy cattle instead of beef cattle?
6. Name three commodities whose principal production is based on the plantation system, and provide adequate explanations for each case. Locate areas where they are grown.
7. Of the following products, which are produced on the plantation system: rubber, cacao, coco-

nut oil, oil palm oil, bananas, tea, cloves, cinchona, pepper, mahogany, ivory, tapioca, vanilla, chicle, and kapok.

8. Prove or disprove the following statement: Man always uses land to the best possible advantage.
9. Name four important truck-crop areas in the United States, and indicate how they differ in their principal crops.
10. What common problem is found in the agriculture of desert oases and of Mediterranean climatic regions?
11. Among the following, where would you expect to find land drainage needed: Florida, Great Basin, Deccan, northern Chile, Belgium, Campani, Switzerland, Iraq, Greece, Nile Valley.
12. Among the following places, where would irrigation be needed: Imperial Valley, Catalonia, Sweden, Ontario, Tibet, Western Australia, Malaya, Guinea Coast, Algeria, Iceland.

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CHAPTER 19: *Mineral Resources*

Minerals comprise one of the most valuable of the world's resources and in one form or another are essential to man; they are so important at the present time that without them he would find it impossible to maintain the present standards of living in most parts of the earth. Without minerals, even human health would suffer, for salt as well as small amounts of other minerals are essential for human growth and well-being. The presence or absence of supplies of iodine and fluorine in human food may mean the difference between good health and poor health, and other minerals are equally important to our existence.

Most phases of our civilization depend upon metallic minerals in one form or another. Our machines are made of metals and run by mineral fuels, and our railroads haul more freight of mineral origin than rail freight of all other sources combined. Much of our trade with other nations, and indeed international trade in general, is made up of shipments of minerals, for Western civilization is dependent on mineral products for much of its raw material for manufacturing. The United States and Soviet Russia are best supplied with mineral reserves, but even they must import some minerals that are not found in quantity within their vast territories; and such nations as Italy and Japan must import most of their mineral requirements or seek sources of supply by conquest of other lands. The peak value of minerals produced in the United States in any one year was reached in 1947, amounting to $12,400,000,000.

The primary occurrence of minerals depends upon conditions in the geologic past that favored their deposition or accumulation. The mineral fuels (coal and petroleum); many building materials, including clay for brick; and minerals like salt, gypsum, phosphate rock, and potassium salts are associated with sedimentary rocks. Deposits of metallic minerals are usually associated with igneous rocks. Secondary deposits of minerals have been moved by some agent such as water; and these resources include (1) the *placers* of sand and gravel containing gold, platinum, tin, precious stones, or other hard insoluble materials that have been reworked by running water; (2) the salines, like the nitrates or borax, which have been first dissolved in water and then precipitated from solution; and (3) secondary enrichment of ores where metals were leached out by circulating ground water from the upper part of a deposit and then precipitated elsewhere, usually at lower levels.

Development in Use of Minerals. The mineral resources of the earth have been used to some extent since prehistoric times. Primitive man shaped rocks for axes, hammers, and pounders, and he chipped flint and obsidian (natural glass) into arrowheads, knives, and spear points. Bits of native copper and meteoric iron were eagerly searched for and utilized. As man evolved from his primitive condition into a civilized manner of life, his need for minerals and his utilization of such wealth likewise developed. First to be discovered were bright metals like gold, silver, and copper that could be recovered with simple methods. He also learned to quarry stone and to heat clay and make pottery, bricks, and other products. The discovery of iron opened new opportunities to build tools and machinery, enabling an individual to accomplish vastly more in a given time than with stone, bone, and wood implements. During the last century or two, there have been remarkable advances in the discovery, extraction, and utilization of mineral resources; and modern life would be impossible on its present level without the metals, fuels, and other minerals.

Technically most minerals have a definite

chemical composition, are composed of one or more elements, and possess characteristics by which they can be identified. Rocks are made of one or more minerals; limestone rock consists of one mineral, calcite, while granite is a mixture of several minerals. The proportion of a certain mineral in a given rock may vary considerably. Rocks from which metals or other valuable minerals can be profitably extracted are called *ores*.

Methods of mining ores and recovering metals therefrom are constantly improving. With each increase in scientific management of mines, smelters, and refineries, it becomes possible to cheapen costs, which makes it possible to utilize deposits that previously could not be exploited profitably because of their low grade or for some other economic reason.

The search for minerals leads into the remote parts of the earth. Mining has become a principal industry of numerous mountainous and hilly regions. Some minerals, like nitrates and borax, come from deserts. Several minerals, especially fuels and building materials, commonly occur on plains. In some high mountains the mining communities form the chief populated centers. Food, machinery, fuel, and other supplies must be imported to the mining towns in deserts and mountains; and railways and highways are therefore required. Thus mining leads to exploration and settlement of some regions that would otherwise be nearly uninhabited. The persistent search for tin ores in the time of the Phoenicians, gold and silver during the time of Pizarro and Drake, and gold in 1849 and 1898 led to the peopling of distant parts of the world, the establishment of permanent towns and cities, and the successful utilization of lands that had hitherto been unknown or unexplored. Indeed, the search for the world's minerals is one of the strongest motivating forces behind world exploration.

Metals

Metals are elements that, with some exceptions, possess a typical luster, are often hard, and can be melted, drawn into wire, or rolled into thin sheets. These properties make metals of great use in our modern world. The first metals found by primitive man were those which occur in the native state, like gold and copper. Later man learned to heat iron ore with charcoal and reduce the compound to metallic iron by the process of smelting the ore. The ancient Greeks, Hittites, and Romans were familiar with gold, silver, iron, tin, lead, zinc, and quicksilver. They also used various nonmetallic minerals like sulphur, salt, and glass sand, and construction materials like lime, gypsum, clay, and building stone. The widespread and intensive utilization of metals dates from the beginning of the industrial revolution. As much iron was produced in the 40 years following the Spanish-American War as in the preceding 4,000 years since its first discovery. Almost as great increases can be noted in the production of copper, tin, lead, and other materials used in modern industry.

Occurrences of Metals. Most deposits of metals are associated with igneous and certain highly metamorphosed rocks, although sometimes iron deposits like those at Birmingham, Alabama, are associated with sedimentary rocks, as are also a few of the lead, zinc, copper, and radium occurrences in various regions of the earth. Generally metals are concentrated in veins and other deposits thousands of feet underground and are exposed at the surface only as the result of removal of the overlying rocks by erosion. Some of the very young mountains of the world seem to lack minerals, possibly because erosion has not yet gone deep enough to disclose them. Among the ranges of minor significance for mineral deposits are the Himalayas, Alps, and Pyrenees. Mountains and plateaus formed of lava flows and volcanic ash are likewise generally poor places to hunt for metals. Although the majority of the known deposits of metals are

in mountainous regions, ore deposits may occur in relatively level country, in part where former mountains have been reduced to plains, as in Canada between Lake Superior and Hudson Bay, and in the interior plateau of South Africa.

Whether in mountains, deserts, plains, or tropical jungles, ores must be mined at the place of their occurrence. Generally speaking, unless a mineral has high value for its weight, as do gold, platinum, or precious stones, cheap transportation to world markets is an essential for successful mining. Remote regions like Alaska, Siberia, and New Guinea can produce gold because its value far exceeds the cost of transportation; but deposits of cheap metals like iron, lead, or copper require accessibility to railroads or steamships in order to be worked profitably.

Iron. Iron today is universally recognized as the metal most essential to man. Those corporations which are engaged in mining, smelting, and manufacturing iron are among the largest establishments in industry. Some of these concerns have iron mines, railroads, and steamships to transport the ore to blast furnaces, steel mills, tin-plate plants, and other concerns that make every iron product that man uses.

The uses of iron are so numerous that enormous quantities are being consumed. Although iron makes up nearly 5 per cent of the weight of the earth's crust, most of the rocks containing iron are unsuitable sources of the metal because it would cost more to extract the iron than it would be worth after smelting. The reserves or high-grade iron ore where the iron content averages between 50 to 70 per cent are not inexhaustible. Iron, like other metals, should be used economically and not carelessly wasted in mining or use. The rusting of iron may be prevented if it is covered with paint or a film of tin or zinc. The addition of small amounts of other elements to iron produces a much harder and more enduring steel than was formerly available. Then too, after machines and other articles made of iron have served their period of usefulness, they should be utilized for scrap, which is an increasing and important source of iron.

The ideal condition for cheap iron and steel production is to have the iron ore and coal for making the coke used for fuel in proximity to each other. Under these circumstances, iron may be profitably extracted from low-grade ores that carry only 20 to 30 per cent iron. Examples of such favorable locations are at Birmingham, Alabama; Newcastle, England; and in the Ruhr Valley in Germany. If the iron and coal are separated geographically, the iron ore usually is transported to the coal, because it takes about 2 tons of coke (equivalent to about 3 tons of coal) to smelt 1 ton of iron ore.

Iron and Steel Production. The greatest iron deposits of the United States are near the shores of Lake Superior in Minnesota and Michigan (Fig. 204). Nearly all the iron ore in these regions is brought by ore carriers from ports like Duluth, Superior, and Marquette to the lower Great Lakes and either smelted at the lake ports where the ore and coal meet, as at Gary, Cleveland, and Buffalo, or taken inland from discharging ports like Sandusky, Lorain, and Ashtabula, Ohio, to Pittsburgh, Youngstown, and other centers in the heart of the coal fields. Some of the ore of the Mesabi Range in Minnesota is so soft it can be mined by mechanical shovels in open cuts, but in Michigan the ore is harder and is generally produced from shafts. The ore is handled by large-scale machinery, and the transportation on the lakes is the cheapest transportation per ton in the world (Fig. 205).

The manufacture of iron and steel in eastern Pennsylvania was based originally on charcoal and next on anthracite coal for smelting local supplies of iron ore. Now coal is imported from western Pennsylvania to make into coke, and most of the supply of iron ore comes from abroad, mainly Chile and Cuba. It is actually cheaper to transport iron ore thousands of miles from Chile by boat through the Panama Canal than it is to bring the ore from Minnesota by railroad, a much

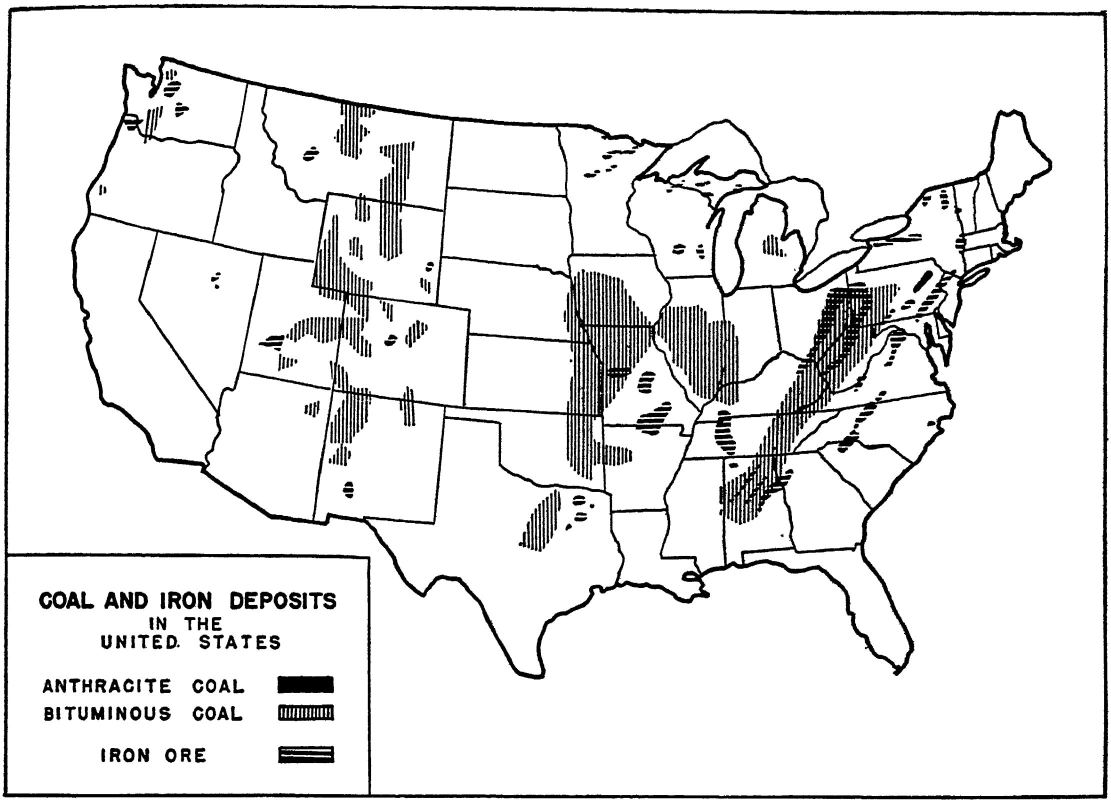

FIG. 204. Coal and iron deposits in the United States.

shorter distance. For convenience some of the iron and steel plants are located on the seacoast, notably near Baltimore.

The most important industrial nations of the world, including the United States, England, France, Germany, and Belgium, are generally those having access to deposits of iron ore. Where nations like Italy or Japan lack important deposits of iron, they are handicapped seriously from the industrial standpoint and in their national defense efforts.

Deposits of iron ore are widely distributed throughout the world. In the United States iron ore is mined in Utah and Wyoming, but the bulk of the ore comes from Minnesota and Michigan, with New York, Pennsylvania, Virginia, Wisconsin, and Texas contributing to the total. In Europe, England, Germany, France, the U.S.S.R., Sweden, Austria, Poland, Spain, and Czechoslovakia are producers of iron ore. Reserves of iron ore are smaller in Asia; but China, India, Siberia, Korea, Manchuria, and the Philippines have important deposits; Japan's iron-ore resources are relatively small. Ore is exported from North Africa, especially from Algeria. Australia has important deposits which are smelted at Newcastle, New South Wales. Brazil has enormous deposits in Minas Geraes and has recently established a steel plant. Chile, Cuba, and Newfoundland are all large exporters of ore, and Canada has big deposits near Lake Superior, Hudson Bay, and in Labrador.

The United States leads the world in both the mining of iron ore and the production of steel. Output varies, and in prosperous years over 90 million tons of ore are mined, from which about 55 million tons of pig iron are derived. The annual output of steel during such a year is about 80 million tons, a figure that is possible because of the additions of

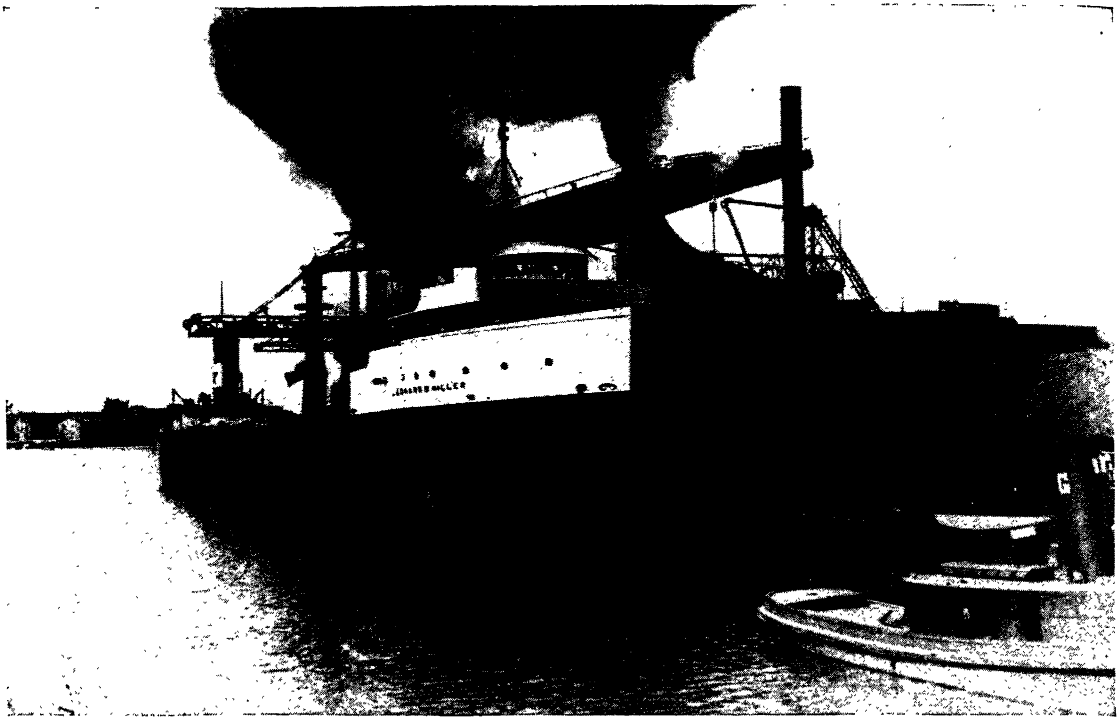

FIG. 205. Unloading Lake Superior iron ore by mechanical means at a Lake Erie port. (*Photograph by James Sawders-Combine.*)

scrap iron to the furnace charge. The iron and steel production of the United States is nearly as much as that of the rest of the world.

Copper. Copper, next to iron in tonnage produced and consumed, has been known and mined for thousands of years. Some of the American Indians made implements of native copper. The extensive use of the metal began with the demand created by the invention and manufacture of electrical machinery, and nearly as much copper has been mined since 1900 as in all the preceding centuries. The United States produces about 850,000 tons of copper annually, which is approximately one-fourth of the world's supply of copper. By ownership of foreign mines, however, our corporations control about two-thirds of the world's copper output. The foreign three-fourths of the world's production comes mainly from Mexico, Canada, Chile, Peru, the Belgian Congo, Rhodesia, Spain, and Japan (Fig. 206). Our domestic producing centers are in the western mountain region, especially at Bingham, Utah; Butte, Montana; and at several camps in Arizona. The Keweenaw Peninsula in upper Michigan is the largest producing area in the eastern half of the country. Until about 1900, most copper came from high-grade deposits where the ore averaged from 5 to 10 per cent copper; but in Michigan the native copper could be extracted cheaply, and ore whose copper content is under 1 per cent has been mined profitably.

High-grade deposits of copper proved insufficient to supply the demand of the world created by the expansion of the electrical and automobile industries. When copper soared in price, it brought a great incentive to discover practical means of operating very extensive low-grade deposits. After experimentation, several methods were perfected by which deposits of copper as low as 1 to 3 per cent in content could be mined at a profit where the ore beds are large enough. The new methods

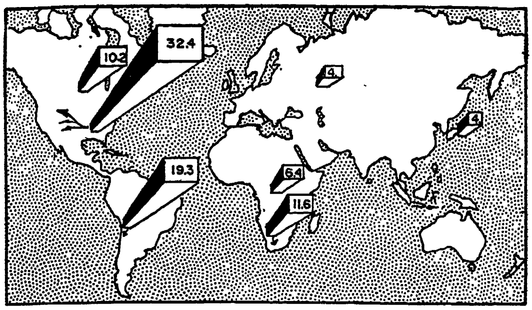

FIG. 206. Principal areas producing the world's supply of copper ore. The figures represent the percentage of world production; minor producing areas are not indicated.

include (1) processes of leaching ore with dilute acid and recovering the copper by electrolysis or precipitation on scrap iron, and (2) concentration of the ore by the oil-flotation process in which finely ground ore is mixed with water and little oil; after agitation, the metallic particles collect in a froth that forms on top of the tank, thus separating the valuable metal from the worthless sand. Improved reverberatory furnaces have been developed for smelting copper ores. By such means, copper is produced at lower costs, and the increased demands from the world have been supplied. Thus scientific research has changed what was formerly worthless rock containing a small amount of metal into valuable reserves of ore.

Lead, Zinc, and Silver. Lead and zinc ores commonly occur in closely related geographical locations, as around the Ozarks. The total United States production of lead is about 350,000 tons and of zinc about 500,000 tons; but the output varies, depending on the market and prices for the metals. The United States mines more lead and zinc than any other country. Lead and zinc deposits containing silver are common in Idaho, Utah, and other western states. Canada, Australia, and Mexico are rich in lead and zinc; and Burma, Russia, Poland, and Spain are other producers.

Lead and zinc are used extensively in the manufacture of paints, an unfortunate practice from the standpoint of conservation, since the minerals are not recoverable when so used. If lead is used for pipe, storage batteries, conduits, and many alloys, much of the metal is later recovered in the form of scrap and can be used again. The substitution of mineral earths for lead in paint would lessen the demand for the metal by about one-third.

The silver in the United States is produced mainly as a by-product metal, from the copper mines at Butte, the lead mines in Idaho, and some of the gold mines. In Mexico and Bolivia some mines are worked primarily for silver, but that is seldom the case in the United States. Whenever silver increases in price, however, mines that were formerly unprofitable may reopen. The United States silver production is about 40 million ounces annually—one-fifth of the world output. The largest consumption of silver is in the motion-picture and photography industries, where light-sensitive silver salts are used on film.

Aluminum and Magnesium. Aluminum was a very rare and expensive metal until about two generations ago, when an electrolytic process was perfected to recover aluminum from a type of clay called *bauxite*. Now aluminum has become a very useful metal because of its lightness, resistance to rust, and other properties. Alloyed with steel it forms Duralumin, which is used for the frames of airships, airplane engines, and streamlined trains. The American supply of bauxite comes mainly from near Little Rock, Arkansas, and from British and Dutch Guiana; and the refining of aluminum is carried on where cheap electricity is available, as in New York State, the Tennessee Valley, the Pacific Northwest, and the province of Quebec, Canada. In Europe, France is the leading producer, but Hungary has the largest known reserves of bauxite. Smelter production of aluminum is about 570,000 tons annually.

A competitor of aluminum, magnesium, has recently appeared. It is produced as a by-product from salt brines at Midland, Michigan, and from sea water at Texas City. In the western United States various rocks and salts have served as ores of magnesium, the metal

being extracted by electricity coming from Hoover and Grand Coulee dams. Magnesium output greatly increased during the war years, attaining 144,000 tons in 1944, but it greatly declined thereafter when aluminum became available again. Magnesium is frequently substituted for aluminum, however, and by experiment new uses and alloys containing magnesium have been discovered which should create a permanent demand for the metal greatly in excess of prewar demands.

Tin and Other Minor Metals. The United States has adequate supplies of most essential metals but produces less than 1 per cent of its consumption of tin, which must be imported from British Malaya, the Netherlands East Indies, Bolivia, and Nigeria (Fig. 207). Tin is used in certain alloys, as a rustproof covering over iron in "tin" cans, and in some chemicals. After being worked for nearly 4,000 years, the output from the tin mines in Cornwall, in southwestern England, has declined. Cornishmen, experienced hard-rock miners, have emigrated to almost every mining region in the world and have helped develop many of the methods used in the mines of the United States.

Other metals in which the United States is deficient include nickel, which we obtain from the Province of Ontario just north of Lake Superior; platinum, produced mainly in the Soviet Union, and in Colombia; and several metals that are used to make steel alloys. The United States obtains its supply of molybdenum from Colorado, and we produce more than any other nation; but our supplies

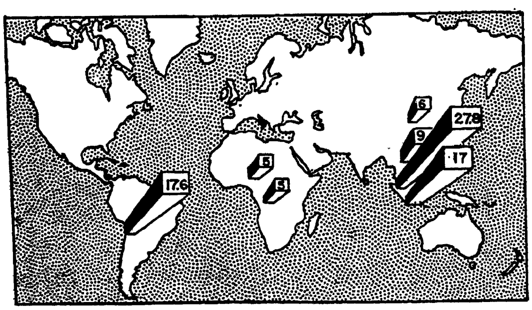

Fig. 207. Principal tin ore mining regions of the world. Figures indicate the percentage of total world production for the leading nations.

of tungsten, chrome, manganese, and vanadium used in the manufacture of special-purpose steels are largely imported. These metals are in great demand during wartime for cannon and armor plate and during peace for tools and machine parts.

Quicksilver (mercury), the only metal that is liquid at ordinary temperatures, comes from Spain, Italy, and Mexico abroad, and some from California, Oregon, and other areas in the United States. Some uses of the metal are in electrical work, dentistry, explosive caps, medicines, disinfectants, silvering mirrors, and in the recovery of placer gold.

Uranium, used as a source of atomic energy, is mined in northern Canada, Czechoslovakia, and Africa.

Gold. Gold is used widely as a standard of value and has probably been mined longer than any other metal. It forms few compounds and occurs chiefly in the native state. When a vein suffers erosion, the heavy and insoluble gold is readily deposited along with sand and gravel to form placers. Simple equipment is needed to recover the gold from rich placers, and gold was secured from such sources even by primitive peoples. No matter how far from transportation or under what severe climatic conditions gold occurs, men can nevertheless produce it and carry it out. Frozen gravels in the interior of Alaska or on the tundras of Siberia are thawed by means of water, and the gold is then extracted by hydraulicking and dredging. When rich placers have been worked out by hand methods and simple machinery, the low-grade deposits that remain may be worked by enormous and very efficient machines called *gold dredges* (Fig. 208). These can operate under favorable conditions on "dirt" that will produce as little as 10 cents worth of gold per cubic yard handled. In the United States, California, Alaska, and South Dakota generally lead in gold mining, but gold is produced in almost every other state from the Rockies to the Pacific coast. The Union of South Africa produces from a third to a half of all the gold mined in the world. The Soviet Union is in second place, and Canada and the United States produce nearly

Fig. 208. Small gold dredge at work in stream gravels. A typical scene in the Sierra Nevada and in some parts of the Klamath and Trinity mountains, California. Riffles for washing the gold particles and gravel may be seen at left of truck; discarded boulders are removed by conveyor belt at right. This type of operation is not profitable unless the price of gold is at a high level.

equal amounts. Other producers include Rhodesia, West Africa, Australia, Sweden, Mexico, the Philippines, Colombia, Chile, India, Korea, and Japan. Preceding the Second World War, the annual production of gold was around $200,000,000. Because most mines closed during the war and high costs after the war discouraged their reopening, the value of the gold mined remains below prewar figures.

Gold, as the standard of value for mining, increases in cost of production in times of rising prices. The gold output under such conditions decreases. In hard times gold will purchase more goods and labor, the expense of mining the metal decreases, and as a result the output of gold rises. Again, the price of gold may be increased by statute, thus benefiting the gold producer and making it possible to operate the mines at a profit that would otherwise be too low to pay to keep them open.

Gold mining has led to exploration and settlement of new regions, as previously pointed out, and to wars and the seizing of territory; it has exerted other important influences of finance and history, yet the actual value of the gold produced in the United States in a single year is considerably less than the value of the poultry industry to our country during the same period.

Mineral Fuels

The mineral fuels include coal, petroleum, and natural gas. These are the greatest sources of energy, and our modern industry is largely dependent on them.

Coal. Coal is formed by chemical action on buried masses of vegetable (organic) material that has accumulated in swamps where oxidation was reduced to a minimum, thus

preventing the destruction of the carbonaceous matter.

World Coal Deposits. Coal deposits occur in all latitudes. There is coal in India and also in Svalbard. The most extensive and commercially valuable coal deposits, however, are in the mid-latitudes, in particular those of the Northern Hemisphere. Of the three continents north of the equator, North America leads the entire world in coal resources, having more than two-thirds of the total reserves, which are estimated at over seven trillion tons, while Asia contains more than one-sixth and Europe almost one-ninth of the total. Australia, Africa, and South America combined, however, including land in those continents on both sides of the equator, contain only about 4 per cent of the world's coal resources. Western Europe, the United States, Canada, and China are the favored parts of the world for coal deposits.

Types of Coal. Several varieties of coals are recognized, the most important of which are lignite, bituminous, and anthracite.

Lignite, a brown coal that is usually geologically recent in origin, contains more volatile matter than do better coals. It is used for domestic heating and steam production but crumbles easily and cannot be stored for any length of time. About two-fifths of the world's resources of coal are lignite. Nearly 3 trillion tons of lignite exist in North America, mostly on the Great Plains of the United States and Canada. In Germany some of the brown coal (lignite) is used for making liquid fuels that may be substituted for gasoline in engines.

Bituminous is a most useful type of coal and makes up the bulk of the world's coal produced at present. It is a soft coal but stores much better than lignite and has a greater heat value. Bituminous coal can be used for many purposes, including heat, power, transportation, and the manufacture of chemicals. When a special grade of bituminous coal is heated in ovens and the gas and coal tar that it contains are expelled, a residue of nearly pure carbon, called *coke,* is left. Coking coal has greater value than noncoking grades because it can be used to supply coke for smelting and additional gas, ammonia, and coal tar for industrial and commercial uses.

Anthracite coal has been subjected to so

FIG. 209. Coal-loading machine in operation at the face of a vein in an Alabama mine. Modern machines of this type have reduced the dangers of mining and have increased production. (*Photograph used by permission of the U.S. Bureau of Mines, Department of the Interior.*)

much heat and pressure during its formation that it consists of nearly pure carbon and is free of volatile matter. Large deposits of anthracite exist in China, Indo-China, Wales, and elsewhere, but the supply of our country is almost entirely restricted to northeastern Pennsylvania, where less than 500 square miles of land is underlain with anthracite (Fig. 204). This hard coal is ideal for domestic use, since it burns slowly without smoke or soot, has a high heating value, and is clean to handle.

Coal Mining. Coal beds are often reached through shafts; but the ideal arrangement, where the coal outcrops on a hillside, is to run a drift or tunnel into the hill from the outcrop, which provides easy haulage and drainage. Formerly coal was mined largely by hand methods, but today in the United States coal-mining and loading machines have nearly done away with the heavy labor involved (Fig. 209). Pillars of coal are left to support the roof of the mines, aided by wooden supports as the remainder of the coal seams are removed. Beds less than 2 feet in thickness are seldom mined commercially. Some beds of coal have been found aggregating more than 100 feet in thickness, although this is unusual.

Uses of Coal. Coal is used for heating homes; for generation of steam in factories; for power plants, railroads, and steamships; for smelting and manufacture of artificial gas and various by-products like fertilizer; and for chemicals. Coal tar, a by-product from coke manufacture, formerly was thrown away; but now this worthless-looking black material is used as a raw material by chemists for the manufacture of thousands of different substances, including explosives, dyes, medicines, flavors, perfume, synthetic plastics, and many other things (Fig. 210).

Coal Deposits in the United States and Abroad. Coal resources of the world are most extensive in the Northern Hemisphere in North America (United States and western Canada), western and central Europe, the U.S.S.R., and Asia (China, Japan, India, and Indo-China). Coal occurs in the Southern Hemisphere but in rather limited amounts.

Coal exists in the United States so widely distributed that its utilization depends largely upon an available market. Some thick but inaccessible seams cannot be mined profitably today because of distance from consumers. More than half of this country's known coal resources, estimated at about 3,500 billion tons, are in the Great Plains or the plateaus on either side of the Rocky Mountains, but the production of coal is small from this area because of remoteness from large markets. The United States leads the world in coal production, about 600 million tons being mined annually, of which about one-tenth is anthracite. The most productive coal-mining

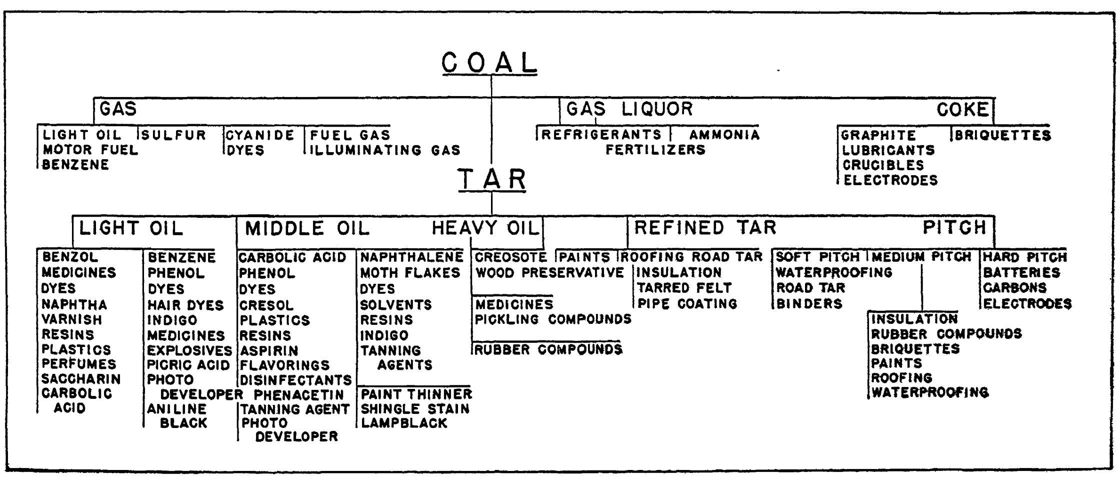

FIG. 210. Some of the commercial products obtained from coal.

region comprises the Appalachian plateaus in Pennsylvania, southeastern Ohio, West Virginia, and southward to Alabama. Coal here is of high grade, and much of it can be used to manufacture coke and various chemical by-products. Appalachian coal provides the nearest source of this fuel for New York and the New England states, regions that lack a supply of their own. Appalachian coal is also exported in large volume to Canada and through Atlantic coastal ports like Norfolk to Europe and elsewhere. Appalachian coal often goes to market by cheap water routes for at least part of the way, since the coal can be conveniently shipped by boat to Canada and up the Great Lakes to regions lacking coal deposits, and by river barges down the Ohio River and other streams, west and southward. In addition, part of the coal-bearing area is highly industrialized, with iron furnaces, chemical works, railroads, and factories of all descriptions consuming great quantities of fuel.

In Europe much of the coal of Great Britain, especially in Wales and around Newcastle, is situated conveniently for export. Ships coming to Great Britain with bulky cargoes of grain, lumber, and cotton were always sure (up to the time of the First World War) of getting cargoes of coal for shipment abroad. This helped British shipping by providing a bulky export from an industrialized country where most exports are of smaller weight and volume than the imports. In the last 25 years a substitution of fuel oil for coal has occurred. In Great Britain export trade in coal has declined, injuring the nation's shipping and industrial position. The most industrialized section on the mainland of Europe extends from northern France through Belgium to the Rhine and Ruhr valleys in Germany and has abundant resources of coal (Fig. 211). Soviet Russia has large coal deposits, and Poland and Czechoslovakia also possess some coal fields.

In the Orient, Japan has small resources of coal and was therefore attracted to Manchuria and northern China in an effort to secure con-

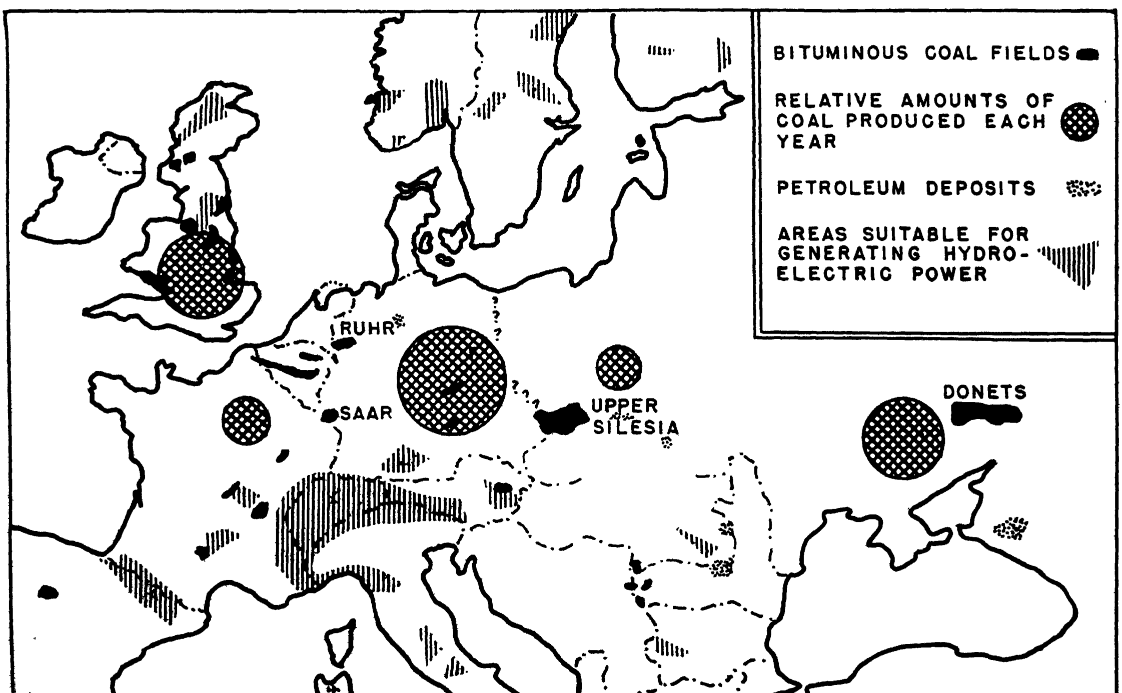

FIG. 211. Sources of power in Europe.

from plant wastes. When petroleum becomes scarcer, some of these possible sources of supply will doubtless be utilized for the energy to operate our automobiles.

Production and Refining. Oil is produced from wells (Fig. 213), of which some have been drilled to depths exceeding 2 miles, but most of the oil comes from wells ranging in depth from a few hundred to several thousand feet. If the water pressure or gas pressure is sufficient, oil wells flow naturally and are called "gushers," but most wells must be pumped to lift the oil to the surface. Then the oil is shipped to refineries, usually through pipe lines—a cheap method compared with shipment by tank car. Special ships called *tankers* are used to transport petroleum and its products by sea. At the refinery the petroleum is successively heated to different temperatures (Fig. 214). Liquids then boil off in succession, beginning with the lightweight naphtha and followed by gasoline, kerosene, and lubricating oil. From the residue greases, paraffin, asphalt, medicines, and multitudes of other products are created. During the Second World War, synthetic rubber was manufactured in large part from a petroleum product. Gasoline is the refinery product in greatest demand. Its output may be increased by sudden heating of crude oil to a high temperature, which "cracks" complex compounds into the simpler gasoline, or by cooling and compressing certain "wet" natural gas to form casinghead gasoline.

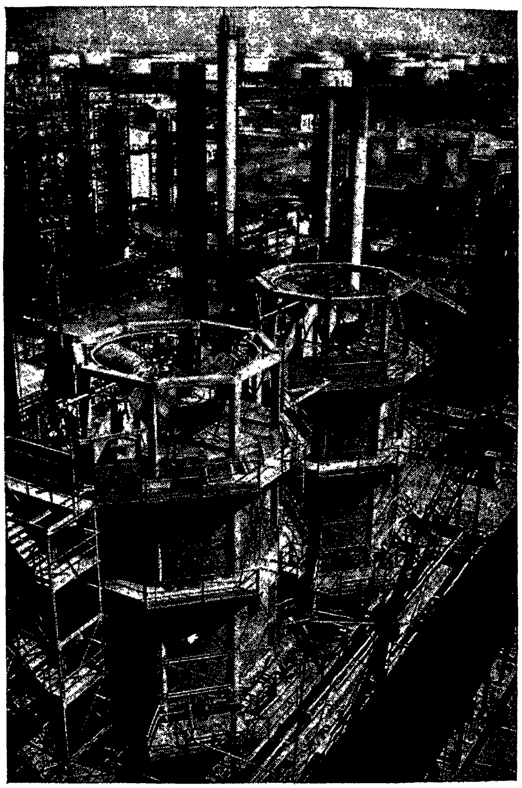

FIG. 214. A modern high-octane gasoline refinery with a tank farm for oil storage in the distance. (Note extensive use of complicated structures, chiefly made of fire-resistant materials.) There is little indication of the original appearance of the landscape; this view represents a scene that is almost wholly the result of human activity. (*Photograph courtesy of the Los Angeles County Chamber of Commerce.*)

The production of petroleum must take place where the oil occurs, but refineries often are located in distant centers of population and at seaports from which the refined products can be distributed easily. San Francisco, New York, and Chicago have no oil fields located in their immediate vicinity, but they are important refining centers.

Oil Fields in the United States. Thousands of individual producing areas for petroleum have been discovered in the United States, but these are especially concentrated in six areas (Fig. 215). These are (1) The Appalachian oil field, which extends from New York to Tennessee, is the oldest known field and is still producing high-quality oil, though production has declined. (2) The Lower Great Lakes field, with producing areas in Ohio, Indiana, Illinois, and Michigan. (3) The Mid-Continent field, centering in Oklahoma and northern Texas and extending into Arkansas and Louisiana. This is the greatest producing field, and its production dominates the petroleum industry in America. Some cities, including Tulsa, Oklahoma City, and Fort Worth, have grown remarkably in population as the direct result of petroleum production in this field; the same is true of hundreds of smaller communities. (4) The Gulf Coast field was for-

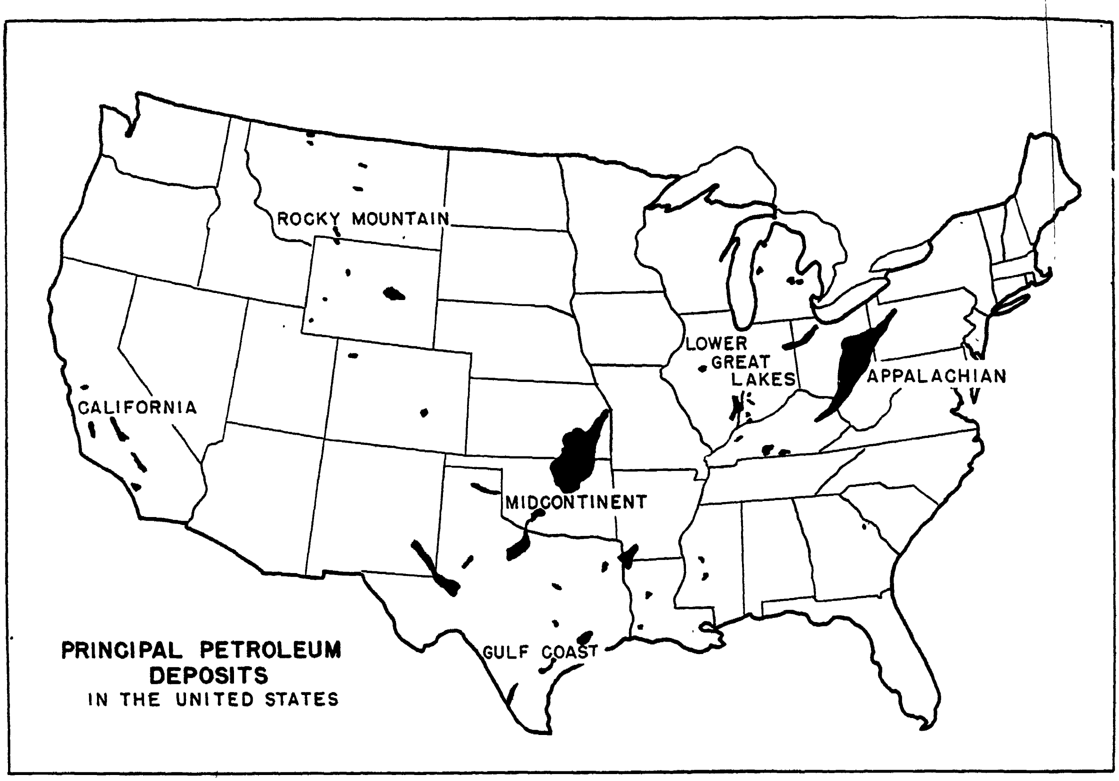

FIG. 215. Principal petroleum deposits in the United States.

merly rather widely separated from the producing areas of the Mid-Continent field; but, with recent discoveries of oil in Texas there no longer is a broad band of nonproducing territory between the two fields. Beaumont, Texas, is the most famous town in the Gulf Coast field. (5) The Rocky Mountain field; this is really a misnomer because the producing areas lie within the boundaries of the Great Plains east of the Rockies or within plateau regions either side of the mountain ranges. The largest production comes from Wyoming, with other known producing areas in Colorado, Montana, New Mexico, and Utah. (6) California, with producing areas of principal importance in the Los Angeles lowland and the southern part of the San Joaquin Valley. Bakersfield, Long Beach, and Los Angeles itself have profited greatly from the oil deposits in California, which is the only important producing field known on the Pacific coast of North America. Smaller towns and cities have sprung up whose entire economic activity stems from petroleum production; of these, Taft, California, is well known.

Production of petroleum by the United States, relying upon the above producing fields, amounts to 1,850 million barrels of oil annually, worth $3,600,000,000, the greatest value of any mineral resource of the country. New oil fields are being discovered, but not so rapidly as known reserves are being exhausted in our nation. Thus it appears probable that the United States will become an oil-importing nation within the next few years, although we shall continue to be a heavy producer of oil for many years to come.

Foreign Oil Fields. Oil fields outside the United States include those on the Gulf coast of Mexico in the vicinity of Tampico; the Colombian and Peruvian fields, and the very rich field in Venezuela near Lake Maracaibo. Oil is produced also in Trinidad and in Argentina and is believed to exist in some quan-

tity in Bolivia and Brazil, though it has not been developed there. In Europe, Soviet Russia leads in oil production by virtue of the great producing field at Baku on the Caspian Sea, followed by Rumania and Poland. Persia, Iraq, Arabia, Burma, and the Netherlands East Indies are the leading producing areas in Asia. Total world production of petroleum amounts to about 2,700 million barrels annually, of which the United States produces and consumes about two-thirds.

Based on inadequate information, world resources of petroleum have been estimated at about 1,000 billion barrels, and production from 1860 to the end of 1948 has been about 60 billion barrels. The petroleum reserves are therefore much nearer exhaustion than are those of coal.

Natural Gas. Natural gas may occur associated with the petroleum deposits or may be found in areas where oil does not exist in commercial quantities. In the latter event, the gas presumably has been derived from coal beds. Natural gas is sometimes used in industry, but it is such an ideal domestic fuel that there might well be restrictions on its use for manufacuring purposes, at least near centers of population. It is especially good for industrial use when it is essential to maintain even temperatures, as in the manufacture of glass. Formerly much natural gas was wasted because of lack of nearby markets, but the invention of spiral-steel welded pipe and ditch-digging machines has permitted the installation of hundreds of miles of pipe line at relatively slight cost, connecting producing gas fields and consuming markets. Today there is much less wastage of natural gas than formerly. Most states now enforce laws that require the capping of gas wells when they are discovered if the gas cannot be used economically at once. Natural gas from Texas wells is now being delivered by pipe line to markets in the Middle West and in the East.

The Importance and Future of Petroleum. Oil is such a convenient and clean fuel to use for steam production and for the operation of motors that the great powers of the world are competing to secure control of the best oil deposits. Where oil is not available, as in Germany, every effort is made to develop substitutes for motor use, even if these cost the consumer more than imported gasoline and are less efficient. Though petroleum has been used for only a short time in the modern world, it is almost inconceivable how the world could get along without it in future. Perhaps substitutes for gasoline could be developed, but there is no known cheap substitute for the greases and lubricants. The enormous increase in the use of machines of all types in this age has been greatly facilitated by inexpensive and abundant mineral lubricants. Our oil deposits should therefore be conserved in every way possible, because the known reserves of petroleum are less than the reserves of coal. Refinements in the production and extraction of oil have advanced greatly in recent years, and there is less waste than formerly; but further improvements in production and utilization can still be made. In the future, large deposits of oil shale in Colorado and Utah will doubtless be used as a principal source of petroleum, although the cost of the product may be higher than that of natural oil. The resources of petroleum contained in the oil shale of the two states have been estimated at 92 billion barrels. Plant waste and coal are both possible substitute sources for synthetic oil products.

Petroleum production, like other forms of mining, is generally a short-lived affair. A field is rapidly developed soon after its discovery. It reaches maximum production, and then comes a period of steady decline, until finally the wells no longer produce and the field is abandoned. The discovery of deeper sands or improved methods of production may, of course, bring renewed activity. Petroleum is sometimes appropriately called "black gold," because it not only produces wealth but also leads to the rush of people to a field, the wild speculation, rapid building, and other excitement that characterized the old-fashioned "gold rush."

Nonmetallic Resources

Construction Materials. Minerals used in construction include building stone; cement; glass; lime; clay products like brick, tile, terra cotta, and gypsum; and other materials. Sand and gravel are generally distributed over wide areas and are so cheap that they are used only to supply local demands. All these commodities are of great bulk; to transport them long distances adds much to their initial cost. For this reason and because glass, building stone, brick, tile, and terra cotta are easily damaged in shipment, they are obtained from sources near where they are to be used.

Building Stone. Building stone should have an attractive appearance, resist weathering processes well, and be abundant and convenient to markets. It should also be obtained from deposits that are easily quarried. The use of building stone has everywhere declined relatively and actua~~lly, compared with other~~ construction materials, during the last half century. This has resulted from the substitution of concrete and other materials suitable for erection by machinery, in place of stone, which requires hand labor. The handicap to the use of building stone is the great amount of hand labor required for quarrying, shaping, and laying the stone. In the Middle Ages, when labor costs were insignificant, stone was the usual material selected for both public structures and the houses of the better classes in southern Europe, but now it is usually used for facing and decoration rather than for the entire walls of structures.

Among the common building stones are marble, granite, limestone, and sandstone, with slate used for roofs and other special uses. Communities close to large cities lead in production of building stone because of the saving on freight from nearby quarries to the cities, as compared with that from remote de-~~posits.~~ Thus Vermont, with ~~its~~ marble ~~and~~ granite quarries (Fig. 216), Pennsylvania with its slate, and Bedford, Indiana, with its lime-

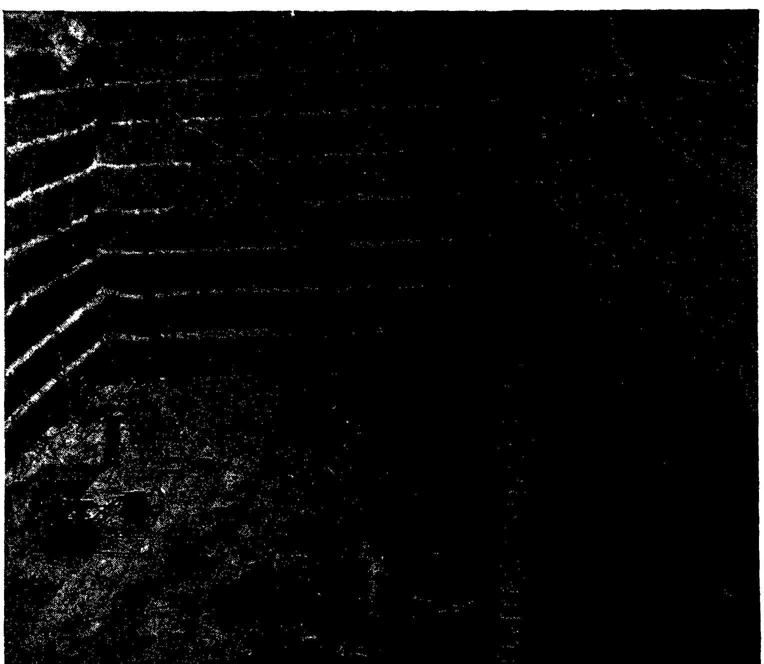

FIG. 216. Men and machines cutting rough blocks of marble at a quarry in Roxbury, Vermont. (*Photograph used by permission of the U.S. Bureau of Mines, Department of the Interior.*)

nitrate is produced now in great quantity, and it supplies nearly three-fourths of the world's needs.

Phosphates. The United States has the largest known deposits of phosphates in the world. Florida and other southeastern states lead in the production at present, but there are large deposits in the western Rocky Mountain region from Colorado and Utah northward through Wyoming and Idaho and into Montana. To change phosphate rock into a soluble fertilizer that plants can use requires treatment by sulphuric acid. This substance may be made as a by-product from smelters using sulphide ores. This should be done, in fact, or vegetation will be destroyed in the vicinity of the smelters because of excessive sulphur fumes. The fertilizer industry is somewhat handicapped in the Rocky Mountain area, however, by the long distances to consuming markets. A nearer source is in eastern Tennessee, where acid is obtained from the Ducktown copper smelter. Since phosphates usually are the most deficient soil mineral, great deposits of this valuable fertilizer are of increasing importance to the United States as the virgin fertility of its soils becomes exhausted.

Conservation and Strategy of Mineral Supplies

The available quantities of minerals vary greatly; some (salt, clay, sand, cement rock, building stone) will last indefinitely and are inexhaustible. Large resources of others are known to exist (coal, iron, aluminum), while some exist in very limited amounts (platinum, beryllium, diamonds). It is in line with conservation practices to use the minerals that are abundant, sparing those in scant supply. The known resources of oil, copper, lead, and zinc in the United States will probably be exhausted within comparatively few years; and, from the standpoint of conservation, we should practice economy in their use in order to make our mineral resources last as many years as possible. Some methods of conserving supplies of particular minerals have been mentioned previously, but general methods for the conservation of mineral resources include the following:

1. Substitution of the inexhaustible and abundant materials for minerals whose quantities are more limited. Water power and hydroelectric power, for example, might replace mineral fuels. Magnesium can take the place of aluminum, and barytes and other mineral earths can be used in place of white lead and zinc oxide in the manufacture of paints.

2. Reduction of waste in mining operations is essential. Improvements in the methods of mining reduce losses from waste; for example, it is unnecessary to leave pillars to support roofs or walls if mining is conducted by open cuts. The removal and use of final residues of ore or mineral fuels from properties where the cost of operations equals or exceeds the selling price is sound conservation policy and practice. Under certain circumstances a guaranteed price or bonus provided by the government for the benefit of high-cost producers may be justified.

3. Development of improved practices leading to more complete recovery of minerals is recommended. More petroleum may be extracted from oil sands; more metal may be obtained from ore; or all of several metals instead of only one or two may be extracted from complex ores. Price increases and improved methods of extraction may change unworkable or unprofitable deposits of oil shale or low-grade ores into profitable mining enterprises.

4. Economies in the use of minerals and the prevention of early deterioration will tend to conserve present supplies of metals. The thickness of the tin coating or tin plate on cans, for example, has been reduced from the amount once thought necessary. Paint and other substances, including plastic cov-

erings, are applied to metal surfaces, thus checking or preventing rust. The development of alloys reduces wear and hence lessens the quantity of scarce metals that may be needed. Marked improvements in the utilization of fuels have taken place; automatic stokers have replaced hand firing of coal; diesel engines are used instead of the ordinary gas engine; and turbines have supplanted steam engines of an older type.

5. The recovery of scrap metals is particularly important. Not all minerals can be reclaimed after they are used; this is true of coal, oil, and lead pigment. Others that can be recovered for further use include scrap iron, copper, tin, and many others. Even silver is recovered from discarded and used film.

6. Synthetic materials and artificial minerals can contribute greatly to the conservation of valuable metals. Substitutes for many minerals are now made by chemical processes. Carborundum is an artificial grinding material, or abrasive. Nitrates for explosives, fertilizer, and chemical uses are made by electrical processes. Certain plastic materials have replaced metals for some uses, as in the manufacture of cutlery handles. Artificial graphite has replaced the natural product for many purposes. Artificial sapphires and rubies have been manufactured with such success that they compete with the natural gems. Artificial soda has largely replaced the natural saline mineral, and fused quartz has partly replaced the natural quartz crystal for many purposes.

7. Conservation of our own valuable mineral resources may be accomplished partly by importing needed materials from other nations. In the final analysis, however, this procedure would have no effect on the conservation of total world reserves.

Strategic Minerals. A special problem exists for those nations which lack important mineral sources to meet their military requirements. Armies, navies, and air forces operate on great quantities of petroleum as well as metallic minerals. Sometimes it is necessary for a nation to conserve its domestic deposits of its valuable minerals to use for emergencies and to import its needs during peacetime.

Those minerals which are absent entirely or are available in insufficient quantities for a nation's armament needs are called strategic. Imports of these minerals may be impossible or very difficult during war periods because of blockades, embargoes, ship shortages, or competitive demands of other nations. Hence nations that are preparing for war may find it necessary to import strategic materials far beyond their immediate needs and to stockpile them for future emergencies. Both Japan and Germany followed this policy from 1935 to 1940.

Minerals occurring in wholly inadequate quantities within the present boundaries of the United States include tin, nickel, chrome ore, uranium, antimony, quartz crystals for radar, and industrial diamonds. Critical minerals of which the United States imports a substantial share of its needs include bauxite, mercury, tungsten, asphalt, mica, asbestos, and platinum. Other nations have different needs; England must import nearly all minerals except coal, iron ore, and part of her supply of bauxite.

The location of mineral resources frequently has influenced routes followed by invading armies; it has also affected the settlement of national boundaries upon the conclusion of wars. Germany, in her three wars with France since 1870 and in her invasion of Russia in the last war, is an example of this development; to a less extent, Japan also supplies an example in her temporary occupation of mineral-bearing lands in China and the Indies, from which she could obtain supplies of oil, tin, and other materials in which the Japanese islands were deficient.

Characteristics of Mining Towns

Mining towns are often of a characteristically temporary construction. It is recognized that most mining communities are short-lived; hence their buildings tend to be built of wood or some other impermanent materials. Later, if the mines or oil wells prove exceptionally persistent and productive, substantial permanent structures will be erected. This type of development occurred at Butte, Montana, in the midst of copper mines, and at Tulsa, Oklahoma, with its rich oil deposits. When the mines are worked out promptly, there is no great loss to property owners if the town has been built of temporary materials. Mining regions usually have many "ghost towns" where a boom subsided or the minerals were exhausted. When residents of these towns depart, buildings burn or fall into decay (Fig. 86), and the settlements may be almost completely abandoned. Mining centers emphasize utility rather than appearance. At Butte, the landscape appears as a confused mass of intermingled shaft houses and hoists, substantial brick buildings, workers' shacks, and other nondescript structures. Sometimes fumes from smelters destroy vegetation and make it difficult to maintain grass and other greenery. Shortage of water may lead to the same barren appearance of mining towns in deserts as at Kalgoorlie and Coolgardie, Australia. No mining town is ever permanent unless other industries follow the mining development, as general manufacturing and other industries have developed in some of the coal and iron towns of the eastern United States and some of the oil towns in the Middle West. Another example of change is found in Colorado, where mining centers have later capitalized on scenery and climate and have catered to health seekers and tourists.

Because the coal-mining community's private capital is oftentimes not available for building houses for workmen, they may be provided by the mining company. The results of multiple home building have sometimes been undesirable, since the houses are arranged in regular rows and are of similar appearance, and little attempt has been made to beautify them. Similar temporary structures in towns may be found around some sawmill centers and construction towns where a large dam, railroad tunnel, or other projects are being built. When the coal is worked out, the forests cut down, or the job finished, these company towns join the metal-mining centers as ghost communities.

The term "gold rush" has been used as a synonym for any mad influx of men seeking quick wealth. History records many actual gold rushes like those of California in 1849 and of Australia and the Klondike in later years. Today the gold prospector may travel by motorcar or by airplane over remote parts of the earth looking for favorable ground, rather than going afoot or on burro or using a canoe. In this generation more excitement comes from the reported discovery of petroleum that from gold mines, and the rush for the "black gold" has replaced that of the literal article. When a wildcat well is reported to have come in a gusher, hundreds and possibly thousands of men hurry to the site. A new town is started, or perhaps a small nearby community begins to boom. The men engage in a mad scramble for the purchase and lease of likely ground. Companies are organized and many new wells spudded in. Hastily built wood-frame hotels and false-fronted business blocks and cabins are built. Many people live in tents; others rent cabins at prices that will pay the entire cost of construction in 12 months. There is a lack of school facilities and often a lack of law enforcement. Gambling and liquor consumption resemble an old-time cattle town when the cowboys are paid off or a lumber town at the end of a log drive. The "boom" may last for several years or may be over in a few weeks. Sooner or later wells on the outside of the producing

territory come in dry (a term that may also refer to a water well instead of an oil well), and then the land underlain by oil deposits becomes known. The field then settles down to a steady production that may last for many years, but the wild excitement and the possibilities of gamblers' profits are things of the past. In large fields, a boom town may develop into a prosperous refining and distributing center with a permanent and substantial base for continued prosperity, but more often the opposite is true. Any oil town has its special population of promoters, geologists, drillers, and other workmen who follow new discoveries from field to field and give a particular atmosphere to the community.

Problems

1. What raw materials of mineral origin for manufacture are imported into your locality?
2. What metals, mineral fuels, or construction materials are produced in your locality?
3. How did mining affect the exploration and settlement of the West?
4. From what areas does the coal used in your locality come?
5. What are the sources that supply petroleum products to your locality?
6. What are the principal uses made of iron in your locality?
7. What are the principal metals used in an automobile?
8. What are some minerals of great military importance?
9. Why do the inhabitants of a mining community fluctuate in numbers and prosperity?
10. How is petroleum obtained? Make a small sketch to show the arrangement of gas, oil, and water occurring in the rocks of the earth.
11. In how many ways is crude petroleum transported?
12. What are the principal centers of cement production in the United States?
13. What quality of copper makes it of special commercial importance?
14. In which of the following would you find profitable copper ores: northern Chile, Ohio, Ireland, Minnesota, Arizona, Germany.
15. State four reasons why the iron ores of northern Minnesota are important to the United States.
16. What natural conditions in past geologic periods determined the present locations of our coal fields?
17. What are factors that determine the sites at which coal mines are developed?
18. Why are estimates of reserves of coal more accurate than those of petroleum?

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CHAPTER 20: *Water Resources*

Water in itself is one of the most important necessities of man's life. It is required for the support of animal and plant life, takes part in erosion and weathering of rocks, and is an essential in many chemical and industrial processes. Water has many uses, including municipal and domestic supply, steam production, manufacturing processes, transportation, irrigation, and power development. A considerable quantity of fish for food comes from inland waters, which also are used extensively for recreation.

Domestic and Industrial Supplies of Water

Domestic water supply should be abundant and easily secured; free from bacteria and other contamination; free from soluble salts like lime, gypsum, and the alkalies; free from odor, taste, and color; and free from suspended matter like mud or silt. Not all cities or regions have abundant water with the qualities desired. In deserts it may be difficult to find enough water for the few ranches located there, and railroads may experience difficulty in getting soft water for locomotive use. In regions that have been long cultivated as in northern France, and particularly where human wastes are used for fertilizer as in China and Japan, the water supply from surface streams and shallow wells is almost certain to be contaminated. Possibly the habit of drinking boiled water, which tastes better with tea leaves added, has become a custom in China because of the danger of drinking the available water. The habit of drinking light wines in France and Italy may save the inhabitants from disease that might follow the consumption of contaminated water supplies.

Where water supplies contain lime or gypsum, the water is called "hard," and much soap is required in order to make suds. Laundries and some other establishments requiring soft water find these hard supplies undesirable. In England at the cotton milling city of Manchester, both ground and surface water supplies may contain chemicals derived from coal beds underlying the region, and such water is entirely unsuitable for use in bleaching and dyeing. As a result these processes are conducted in plants close to the Pennine Hills east of Manchester where supplies of soft water are secured from a pervious sandstone.

Urban Water Supply. Large cities have a serious problem in securing sufficient supplies of pure soft water for their residents. New York and Los Angeles have experienced outstanding problems in their water-supply situation.

New York found her local well water and similar supplies inadequate for her needs many years ago. The city authorities undertook to develop a source of municipal water supply at the Croton reservoir on the eastern side of the Hudson River. Before many years elapsed, this source likewise proved wholly inadequate, and additional water was then obtained from the Catskill Mountains. An aqueduct 18 miles in length was built to carry the water to New York City. The areas that supply water are kept wooded, and the watersheds are generally free of residents. En route to New York the water is brought under the Hudson River by means of a large siphon. The problem of supplying the city with water is complicated by the location of New York on Manhattan Island, which requires tunneling far beneath the mud and water through solid rock. Other tunnels are needed to supply Brooklyn and Staten Island.

Los Angeles, finding that the local supply of water was inadequate for the growing city, developed a supply on the eastern slopes of

the Sierra Nevada in Owens Valley (Fig. 166) and brought this water for a distance of 260 miles across the desert in a gigantic aqueduct. As this city grew, the supply of water threatened to become insufficient, and Los Angeles and nearby cities have therefore spent large additional sums to build an aqueduct from the Colorado River. This water must be pumped across the desert and over the mountains to reach the coastal cities; this is accomplished by using electrical energy produced at Hoover Dam. The water is taken from the river at Parker Dam, some miles south of Hoover Dam, and it is therefore comparatively free from silt. In fact, most of the mud that gave the Colorado its name is now deposited upstream from Hoover Dam in the large reservoir known as Lake Mead (Fig. 218). Eventually the dam will impound so much silt that its functions will be destroyed; it has been estimated that this will occur in about 200 years. Until then, however, the water that passes through the power plants at the dam provides a wealth of energy for the use of the cities as well as for pumping water across the desert. Lake Mead also provides a desert recreation center with boating and resorts, and the dam itself is an important tourist attraction. Water for irrigation of the Imperial Valley is obtained from dams located along the river downstream from Hoover Dam. Most of the water reaching Los Angeles from the Colorado is too expensive to be used for irrigation, and consequently it is used principally for industrial and domestic purposes.

Cities on rivers and lakes have large quantities of water available; but, as their populations increase, the supply becomes contaminated from towns upstream or settlements along the lake shores because bodies of water are convenient places for sewer outlets as well

Fig. 218. Hoover Dam on the Colorado River, impounding a lake known as Lake Mead in the heart of the Colorado desert. This dam has two principal purposes: (1) prevention of floods on the lower Colorado River, and (2) production of hydroelectric power for use in southern California cities. The landscape is desert in type. (*Photograph courtesy of the U.S. Bureau of Reclamation, Department of the Interior.*)

as for water intakes. Sooner or later trouble with contamination causes typhoid fever and other intestinal diseases. If lake and river water are filtered through layers of sand and charcoal, the suspended silt and some of the danger of contamination are removed. To make water perfectly safe, however, a chemical such as chlorine may be added to destroy the bacteria.

Chicago's Water Problem. The city of Chicago is located near the southern end of Lake Michigan, on the land divide that separates water flowing into Lake Michigan and the St. Lawrence from water flowing into the drainage basin of the Mississippi River. When Chicago was smaller, it obtained a supply of good water by pumping from Lake Michigan; but, as the population increased, the lake water became seriously polluted with surface and sewage drainage. To overcome the difficulty, a sanitary district was organized in 1889, and under its direction a drainage canal was built, using the Chicago River as a channel. Normally this stream emptied into Lake Michigan, but an excavation of only 10 feet reversed its flow and sent its waters into tributaries of the Mississippi. Then, by pumping water from Lake Michigan into the drainage canal, the city's wastes could be flushed away from the lake instead of toward it. As long as Chicago remained a relatively small city, no great amount of water was needed; but, as the city grew, it required more water. By 1907, the large amounts of water taken from Lake Michigan by the city were beginning to affect the shipping channels, piers, canal depths, and other features of navigation on the Great Lakes, and the Canadian government protested. The withdrawal of nearly 10,000 cubic feet of water per second (a volume greater than the flow of the American Falls at Niagara), in combination with several years of reduced rainfall, lowered the levels of Lakes Huron, Erie, and Ontario from 5 to 7 inches, and the harbor at Montreal from 9 to 10 inches. This greatly hampered shipping, made canals unnavigable, and generally created serious hazards throughout the Great Lakes region. The entire situation was reviewed by the courts and became a matter of some international consequence before Chicago was required to reduce the daily consumption of Lake Michigan water and establish a system for the disposal of sewage and industrial wastes without impairing the levels of four of the Great Lakes as well as the St. Lawrence.

Recreation, Health, and Inland Fisheries. Many health or pleasure resorts depend on mineral or hot springs (often both), like those at Baden, Germany; Lourdes, France; Saratoga Springs, New York; and Hot Springs, Arkansas.

The development of the automobile has made it possible for many people to use inland lakes and rivers for fishing, camping, boating, swimming, and other resort purposes. The modern accessibility of resorts on inland waters has caused the development and utilization of many lakes and streams formerly unused.

Considerable amounts of food fish are caught in the Great Lakes and the larger streams. In addition to commercial fresh-water fisheries, quantities of game fish are caught for which there are usually restrictions on both catching and sale in order to protect the species from extermination (Fig. 219). Most men regard fresh-water fishing as a sport rather than a source of food and gladly spend large sums of money for the pleasure. Catering to the fishermen has become a big business in some sections like Maine, northern Wisconsin and Michigan, Colorado, and Ontario.

In some countries, notably China, quantities of fish are raised for food in artificial ponds. It is reported that more weight of food can come from a pond—fish, bulbs, ducks—than from an equal area of fertile cropped soil.

Stream and Ground-water Pollution. Many rivers in the United States are seriously polluted. Too often the stream bed has served as a dumping ground for all kinds of refuse, and

FIG. 219. Celilo Falls on the Columbia River. This is a traditional spot for fishing; here some northwestern Indians use wooden platforms for salmon fishing as the fish make their way to spawning grounds farther upstream. Note the modern steel and concrete bridge which crosses the river at the top of the photograph. (*Courtesy of the Seattle Times.*)

former beauty spots have become eyesores and nuisances. Industrial wastes from steel and paper mills, the oil from refineries, and the sewerage of cities unite to contaminate streams. This pollution frequently is so serious that it kills fish and makes the use of water from these streams impossible for human beings. There is serious need in the industrial parts of the United States for action that will prevent this pollution, most of which is entirely unnecessary.

Cities are sometimes founded where large springs are available for use by the inhabitants. In limestone regions solution caverns exist, and much of the drainage is underground. The only reliable domestic water supply may be found at points where the subsurface flow breaks out to form springs. Numerous towns in Greece and Syria were founded at "fountainheads." In limestone regions, great care must be used to avoid water supplies that are contaminated.

Water Power

Water power has served man as a source of energy for many centuries. The energy of swift-flowing water was used to operate water wheels in the Near East, to lift water for irrigation purposes in Egypt, and as a source of power along streams in China. This power for grinding of grain and the operation of other small manufacturing plants came from old-fashioned water wheels in many parts of Europe and colonial America, especially in

New England. Many important industrial centers of today received their early impetus from the harnessing of the energy of a waterfall.

Factors Affecting Water-power Use. Flowing water constitutes a source of energy that can be used indefinitely, and the development of hydroelectric power is one of the best ways to conserve coal and petroleum. Favorable sites for the development of water power result from several causes, notably from the outcrop of resistant rock material in stream beds. This causes waterfalls and rapids and creates narrow gorges or canyons that are desirable locations for dam sites. Waterfalls along the fall line (Fig. 158) and within the Appalachian Piedmont and New England regions are frequently caused by resistant rock strata. Occasionally this type of bedrock forces rivers to change their courses or their valleys, thus providing for the formation of power sites. Many power sites of this type occur in the northern United States and northern Europe as the natural result of glacial erosion and deposition.

A good power site should have a large amount of water falling a considerable distance, and the flow should be steady. If it is to be developed for electrical energy, a nearby market should be available. An ideal situation is that at Niagara Falls, where the river drains the Great Lakes and therefore has very steady flow and large volume, falling 150 feet, with nearby manufacturing centers that can make effective use of the available power. Lakes are an advantage in maintaining regular flow of streams; this is a great help in producing a steady current of hydroelectric power. The Great Lakes and other glacial lakes provide many examples, as well as the artificial lakes impounded by dams, as at Lake Mead.

Geographical conditions are sometimes unfavorable for the development of power; for example, since the fall of the Mississippi River is only a fraction of an inch per mile below Cairo, Illinois, it naturally has no good power sites on its lower course. African rivers are large in volume of water as they plunge over the edge of the central plateau not far from their mouths, but these rivers have no nearby markets for hydroelectric power. Africa has more water power than any other continent, but the amount developed is small. The same is true of the vast power resources of eastern South America and southern and eastern Asia.

Water Power in the United States. The potential water power available in the United States for 90 per cent of the time is estimated at 35 million horsepower, and that available for 50 per cent of the time at 55 million horsepower. Nearly two-fifths of the potential water power of the United States is located in the three Pacific Coast states, and more than half is in the five states of California, Oregon, Washington, Idaho, and Montana. Power has been developed rapidly in the Pacific Northwest, partly at the government power plants at Bonneville (Fig. 220) and Grand Coulee on the Columbia River. Together they ultimately can produce nearly 3 million horsepower, although the actual present development totals only half of that amount. Still the development in the northwestern states compared with their amount of potential power leaves them behind the eastern part of the nation, where a larger available market exists for the sale of electrical energy.

Many of the accessible power sites in New England, the Middle Atlantic, and the North Central states have been developed already, while a relatively small part of the available power in the four northwestern states has been developed. In New England three-fourths of all water-power sites are utilized. In all the United States has an installed capacity of nearly 19 million horsepower of hydroelectric energy, which is about one-half the amount of electricity generated by steam. The leading states in power development are California, Washington, New York, Tennessee, Alabama, Oregon, North Carolina, South Carolina, Nevada, and Arizona. One of the greatest un-

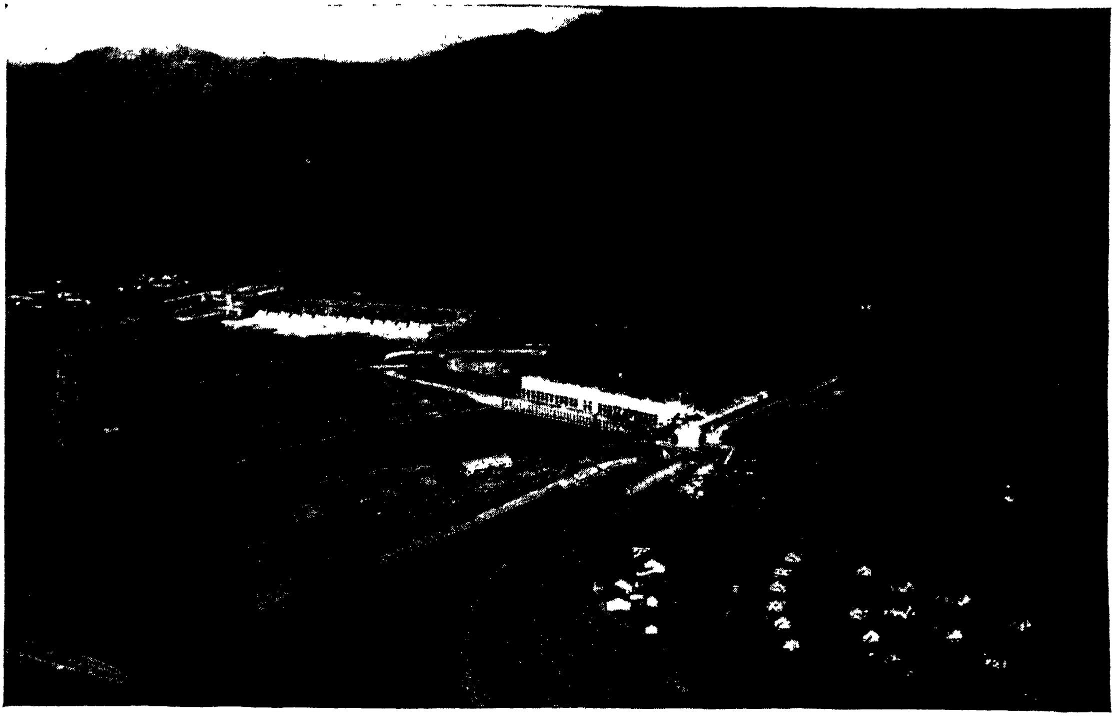

FIG. 220. Bonneville dam, a major power plant in the Pacific Northwest, in its Columbia Gorge setting. Note the large lock at the right of the powerhouse; it can lift ocean-going vessels 70 feet into slack water that now covers formerly dangerous rapids. (*Photograph courtesy of Bonneville Power Administration.*)

developed power projects in the east is that of the St. Lawrence River, and only a fraction of the potential power at Niagara Falls has yet been developed.

Water Power Abroad. The developed water power of the world, according to the U.S. Geological Survey, amounts to 86 million horsepower. After the United States, which leads in its capacity of installed water wheels, the leading countries are Canada and Newfoundland, Norway, Sweden, Italy, the U.S.S.R., Japan, France, Germany, Austria, and Switzerland. A statement of the relative power production of the different nations, however, fails to give a complete picture. In such countries as Canada and Norway, which have abundant water-power resources, the electrical output of the water wheels is greater per horsepower installed than in other countries such as France and Germany, whose resources are not so great. In Canada and Norway only the best sites are utilized, and at these sites only as much machinery is installed as can be operated throughout a large part of the year with the water available; in countries where the demand for power is great and the potential water-power resources comparatively small, machinery is installed to use water power that is available for only part of each year, with the power for the remaining period being supplied by steam.

In Europe, nations like Italy, Switzerland, Austria, and France, having large resources of water power in the Alps and insufficient coal for industrial energy, are leading producers of hydroelectricity (Fig. 211). The same is true in Norway, Sweden, and Finland. Without water power, large-scale manufacturing would be greatly handicapped in Switzerland and Norway. Even the railroads are electrified and run by the energy of waterfalls in Switzerland. The low-lying British Isles have little

TABLE 5. CAPACITY OF ELECTRIC UTILITY GENERATING PLANTS IN UNITED STATES IN 1946, KILOWATTS

Division	*Total*	*Hydro*	*Steam*	*Internal combustion*
United States	50,303,660	14,849,036	34,304,910	1,149,714
New England	3,188,290	892,596	2,272,285	23,409
Middle Atlantic	10,539,234	1,590,945	8,908,622	39,667
East North Central	11,568,270	738,228	10,685,193	144,849
West North Central	3,518,699	562,256	2,531,267	425,176
South Atlantic	6,626,228	2,221,098	4,312,915	92,215
East South Central	3,424,918	2,221,480	1,184,959	18,479
West South Central	2,734,316	385,247	2,112,951	236,118
Mountain	2,678,104	2,004,004	559,488	114,612
Pacific	6,025,601	4,233,182	1,737,230	55,189

available power, and England's abundant coal supply discourages its development. With only peat available for domestic use, Eire has encouraged water-power development. Japan, a rainy and mountainous land with numerous swift rivers, needs power and has rather small resources of coal compared with its needs; thus it is natural to find the country leading in the development of water power in the Asiatic lands.

The potential water power of the world is estimated at 664 million horsepower for the minimum flow and about 1,992 million horsepower for the mean flow. The installed capacity in millions of horsepower by continents is: North America, 36; Europe, 35; Asia, 12; South America, 3.4; Oceania, 1.3; and Africa, 0.37, according to the U.S. Geological Survey.

Use of Water Power. In the past, factories were located directly at waterfalls, the machinery being turned by a water wheel attached thereto. Factories and associated homes of the workmen were often placed in narrow valleys in order to be near the power source. Today waterfalls are no longer important sites for cities. Only the power plant itself need be at the falls, and from there the energy is transmitted to mills, cities, and other consumers.

The development of water power is not always less expensive than energy produced from mineral fuels, since large efficient plants using cheap coal or fuel oil produce power very economically. From the standpoint of conservation, however, it would be desirable to develop all water powers that would not cost more for energy than that produced from coal, in order to conserve the exhaustible fuel. The use of water power, in fact, is a most obvious way to save coal and oil reserves.

To avoid the possibility that consumers of hydroelectricity will lack energy in case of accident to a single source of supply, the power producers commonly have auxiliary steam plants to supply energy in cases of emergency. Also different power plants are tied together by interlocking distribution systems; and if service from one plant is interrupted, energy can be secured quickly through other connections.

Hydroelectric power is an ideal source of energy for plants such as paper mills and pulp mills, which operate 24 hours a day, in that the energy of falling water can be continuously applied to these manufacturing processes. As a result, many of the paper and pulp mills in New England, New York, Michigan, Wisconsin, Quebec, and Ontario are located on rivers down which pulpwood comes to power sites furnishing the energy for operation of the mills. If the site is convenient for lake or ocean transportation, that is an additional advantage.

Uses of Rivers and Lakes

River Transportation in the United States. Inland waterways were one of the earliest methods man used for transportation. The American Indian utilized the extensive system of rivers and glacial lakes for hunting and trading expeditions in the northeastern United States and eastern Canada. Similar routes were followed by French fur traders and explorers. The first outlet for the produce of the agricultural settlements in Ohio and Kentucky was by way of the river to New Orleans, using flatboats and rafts to carry goods downstream. The crude boats were broken up for lumber at the end of the river journey, and the rivermen walked or rode home by horseback. The wealth of lumber from the forests of northern Pennsylvania was rafted down the Susquehanna River to its markets in Harrisburg, Baltimore, and other cities, and the men returned upstate by overland routes. To carry goods upstream, however, was very laborious, whether by rowing, poling, sail, or towrope. When the steamboat was invented, all this was changed and river boats could make good time upstream on the Mississippi, Ohio, Missouri, and other rivers.

For about 60 years during the middle of the last century, river traffic flourished along the Mississippi and its tributaries; boats operated from Pittsburgh down the Ohio and up the Missouri to Fort Benton, Montana, at the head of navigation; to St. Paul on the Mississippi; and to New Orleans down the "Father of Waters." Then competition with the railroads and poor landing facilities brought about a decline in river transportation, and by 1900 traffic had dropped to only a fraction of its former amount. Since then efforts have been made by the government to get people to return to the use of inland waterways. The government established barge lines on the Mississippi and other streams to provide regular service for the public. Some progress has been made in building up the use of our rivers, but the traffic has not attained its former importance.

The Monongahela River carries more tonnage than the mighty Mississippi simply because it is convenient for the coal mines, steel mills, limestone quarries, cement works, and other producers of bulky goods. As a result, the stream has been canalized and carries an enormous traffic, which furnishes evidence that America does not wholly neglect the use of waterways when it is highly advantageous to use them. Passing from the Monongahela into the Ohio River at Pittsburgh, it is possible to utilize a controlled stream, marked by a series of more than 50 dams and lock systems, in making the trip downstream to the confluence with the Mississippi. It has taken the better part of the last century to complete the original plan for the improvement, and the success of the plan is attested by the flourishing cities that now line its course—Pittsburgh, Wheeling, Huntington, Cincinnati, Covington, Evansville, Louisville, and Cairo. Without the advantage of a navigable channel, these and many other towns would have been unable to market their bulky commodities efficiently and cheaply. Improvements in the navigation of the Ohio River have made that stream one of the prime transport units in the world.

The Great Lakes. The cheapest transport per ton-mile in existence lies between the head of Lake Superior and the foot of Lake Erie, for all commodities that can be handled in bulk with a minimum of human labor. Cargoes of iron ore, lumber, and grain coming down the lakes, and coal going up to markets that lack any nearby supplies of mineral fuels, provide a constantly changing stream of shipments during those months when the lakes are ice-free. The government has improved navigation on the lakes by dredging channels, building canals and dams, and surveying and marking navigation channels. No other nations have the marked advantages of a coordinated system of water transport similar to that enjoyed by Canada and the United States.

Disadvantages and Advantages of Rivers for Transport. Rivers possess certain advantages and disadvantages as routes of travel. A river is irrevocably related to its geographical setting—its latitude, extent of basin, direction of flow, volume, and other physical aspects. Hence its usefulness to man must be understood and interpreted in relation to that setting, and the direction in which it trends will determine the flow of river-borne trade within its basin. The demand for trade routes in the United States is in an east-west direction so that goods from the interior can be shipped readily to Europe and products returned. Our largest river system, the Mississippi, flows north and south, at right angles to the needed direction.

Other disadvantages of rivers include widely meandering courses that may greatly increase the distance between towns as followed by a railroad; extreme fluctuation of flow causing trouble with floods; lack of a navigable depth or breadth of water; obstructions to navigation, such as sand bars, snags, and rocks; dangerously swift currents; rapids or waterfalls requiring that cargoes be portaged or canals constructed; navigable lengths of water too short to use economically; trouble with ice, fogs, and other climatic conditions; lack of suitable landing places; and shifting channels.

The two great advantages of rivers are (1) rights of way are provided without cost, although improvements must be made on many river beds to fit them for transportation, and (2) water transport for bulky goods is always cheaper than rail transportation if the waterway connects the source with the market. Thus the Rhine River is the most used stream in Europe though not the largest. The iron ore of northern France is brought by canal to the Rhine and then up the Ruhr Valley to the coal regions. Coal and imported grain are transported upstream and lumber cargoes downstream. Potash, cement rock, and all kinds of construction materials are shipped on barges. The Rhine is a useful stream because it lies in a highly industrialized and densely populated part of the world. The Volga River has large volume, slight current, and a fairly fertile hinterland, but it would be more advantageous if it flowed into the open sea rather than into the enclosed Caspian. The Danube River is much larger than the Rhine, and from its source in Switzerland to its mouth at the Black Sea it flows through or touches many countries; yet it is not used nearly so much as the lesser Rhine because the Danube Basin is not so densely populated or industrialized. Political considerations also enter into the use of the Danube, since the river flows through seven countries. In Asia the Yangtze Kiang connects the interior with the coast and is widely used in spite of trouble in navigation through deep gorges where rapids are a hazard to the boats. The Amazon has the most extensive system, but the small population limits its use. The Ganges, Paraná, Magdalena, Nile, and Tigris are among other useful rivers.

Canals. Canals serve transportation needs in a special capacity: they are built to connect systems of natural inland waterways and provide uninterrupted navigation where unfavorable natural conditions of the terrain would otherwise require portages. The Grand Canal in China was built more than 1,000 years ago and extends for 1,200 miles from Peking southward to Hangchow (Fig. 221). Some of the canals in Europe are centuries old.

The first important canal built in the United States was the Erie Canal, connecting

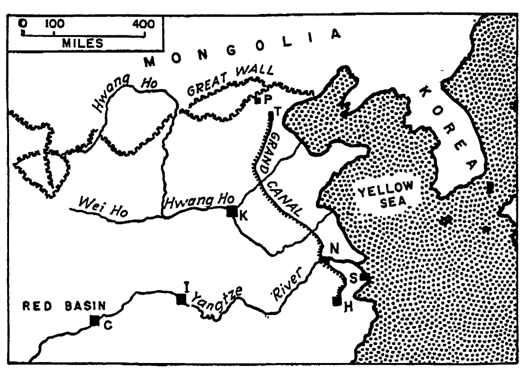

FIG. 221. Grand Canal and the Great Wall of China. *P*, Peking; *T*, Tientsin; *K*, Kaifeng; *N*, Nanking; *S*, Shanghai; *C*, Chungking; *H*, Hangchow; *I*, Ichang.

the Hudson River near Albany with Lake Erie near Buffalo. This canal so cheapened transportation costs from the farm lands tributary to the southern Great Lakes that it greatly assisted their development. In New York State, nine cities with populations in excess of 75,000 lie along the Erie Canal or the Hudson River route. In addition numerous smaller towns are located on the Erie Canal–Hudson River system. When the building of railroads to the West took most of the traffic from the Erie Canal, the state of New York deepened and widened it into the New York State Barge Canal (Fig. 222) in the hope of making this waterway regain its former importance. No important increase in traffic has resulted, however, and bulky commodities like grain, gravel, and iron products are almost the only freight carried on the canal today.

Canals were built during the middle of the last century to connect Lake Erie and Lake Michigan with the Ohio River, across Ohio, Indiana, and Illinois. They utilized several of the tributaries of the Mississippi and Ohio rivers. Most of these canals have been abandoned, since railways and highways seem better able to handle the trade. In the eastern states a canal has been built across Cape Cod, used by steamers traveling between Boston and New York. Another crosses the Delmarva Peninsula between Delaware and Chesapeake bays. On the west coast, a large canal at Seattle connects Puget Sound and Lake Washington by way of Lake Union. Another lock at Bonneville Dam on the Columbia River will permit ocean boats to ascend the stream into the slackwater lake created by the dam and to dock at The Dalles, which is more than 100 miles inland. Houston, Texas, and Stockton, California, have been made into seaports by the dredging of natural waterways into ship canals leading inland to those cities.

The most used canal is that at Sault Sainte Marie connecting Lake Superior and Lake Huron (Fig. 223). In the summer season, when shipping is at its peak, four locks on the American side and one on the Canadian side are constantly operating to keep the great freighters moving around the rapids of the Saint Marys River. The "Soo Canal" is open only about 8 months of the year, but during this time it carries more traffic than the Panama and Suez canals combined, which operate 12 months each year.

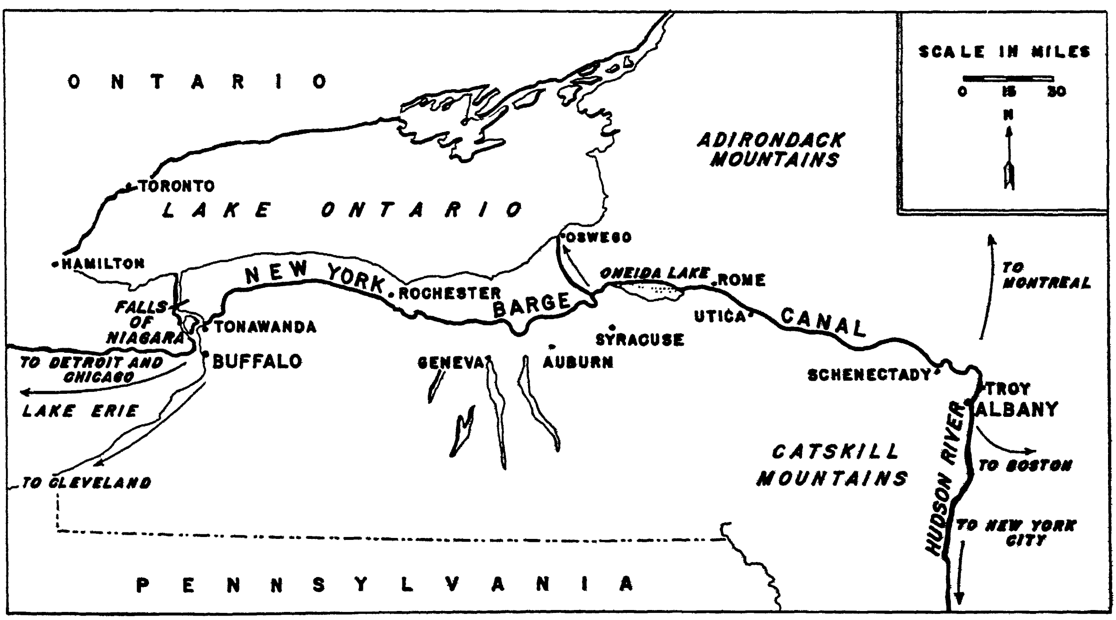

FIG. 222. Erie Canal–New York Barge Canal route across central New York State.

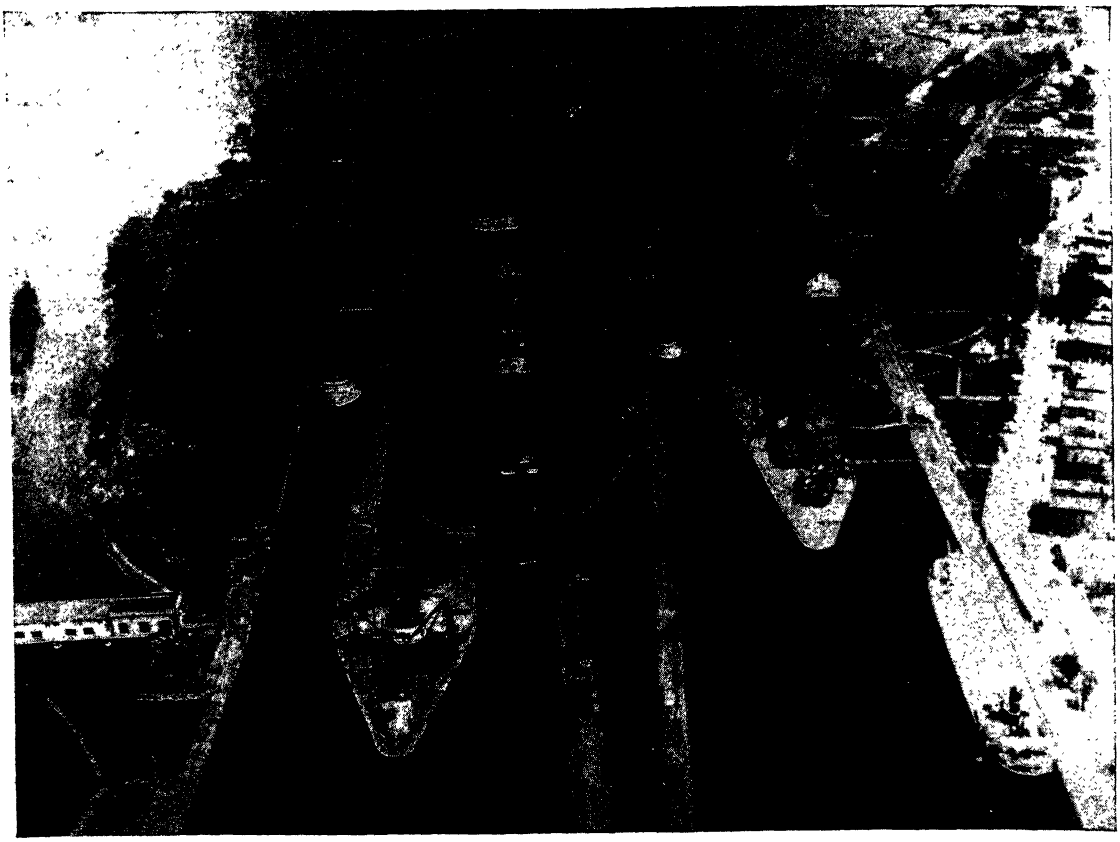

FIG. 223. Soo Canal, looking eastward down the St. Marys River and locks. A powerhouse, using power from St. Marys Falls, is at left. Part of the town of Sault Ste. Marie is at right. Note ore vessels in the canal locks; those headed for Lake Superior ride high in the water because they are empty; those headed for Lake Huron in the distance are filled with iron ore. (*Photograph courtesy of the U.S. War Department, Corps of Engineers.*)

Numerous canals in Europe connect navigable rivers and form a fairly complete transportation network in countries of moderate relief like the Soviet Union, Germany, France, and England. The Low Countries of the Netherlands and Belgium have a complete system of canals, used for both transportation and drainage. The cheapness of water transport is a factor in location of the steel industry in the Ruhr Valley, where iron ore is brought to the coal supplies by canal and river routes. In Russia canals connect the Volga with the Dnieper, the Don, the Dvina, and other streams; though closed in winter, the waterways are nevertheless much used. A ship canal crosses the peninsula of Jutland from the port of Kiel and permits boats to avoid the long journey through two straits and the North Sea. The Manchester Ship Canal in England has made a port of a former inland city. The ports of Amsterdam, Rotterdam, and Antwerp are served by numerous canals. In Germany canals connect the Rhine, the Elbe, the Oder, and the Danube rivers.

Rivers as Barriers. Rivers are useful for transportation, but they also form barriers of more or less effectiveness. Broad swampy flood plains and deltas like those of the lower Mississippi, the Danube, and the Volga are very difficult to cross. Even small streams, if their channels are incised, are barriers to men and transportation. The location of fords, ferries, and bridges affects the selection of sites and the growth of river towns. The names

of many English and American cities suggest this—Oxford, Cambridge, and Harpers Ferry. The great number of streams in a humid climate may compel frequent departures from a straight route to seek a possible way across water barriers. Because cities cannot afford bridges across a wide river on every street heading streamward, bridges tend to become traffic bottlenecks for several blocks on either side of the stream. Even animals sometimes find wide rivers effective barriers to movement. Thus the chimpanzee and okapi are said to live only on the north side of the Congo River and have been unable to cross that stream.

Rivers as Boundaries. "Barrier" rivers like the Mississippi, Rio Grande, St. Lawrence, and Columbia may serve as state or national boundaries. A river valley, however, is an economic unit that should be included in a single political unit, for many rivers occupy shifting channels, and these make the delimitation of a boundary line difficult and subject to controversy. Most rivers produce unstable boundaries and may lead to disputes, as the Rio Grande between Mexico and the United States or the Red River between Texas and Oklahoma have. The latter case gave rise to litigation between the two states regarding ownership of oil deposits beneath the channel of the stream. The usual rule applied to river boundaries is that, if a change results from slow cutting on one bank and deposit on the other shore, the new deposit belongs to the owner of the adjacent land. If the change is very rapid, or catastrophic, however, like the formation of an oxbow cutoff across the neck on an inner meander, the detached area remains the property of the former owner. Under this rule, in the Mississippi flood plain, some Iowa land lies east of the present main channel of the river, and Illinois has land on the west side. A similar occurrence took place on the Mississippi flood plain near Vicksburg in 1876, when a large looped meander was suddenly cut off, leaving the town without river transportation and leaving the Louisiana land within the meander lying east of the river (Fig. 160). The boundary between Mississippi and Louisiana at this point was in dispute for many years. From time to time it is necessary for a river commission to try to effect exchanges of land between Mexican and Texan owners along the Rio Grande, where the channel has changed abruptly and transferred land from one side of the river to the other.

Lakes. Lakes are often useful and pleasurable features to have in a community. They are very irregular in their distribution. Minnesota, for example, has thousands of lakes in contrast to their rarity in Oklahoma and Kansas. Regions that have been recently glaciated usually have numerous lakes. These result from glacial scour, dams of debris dropped by the melting ice, and the irregularity of deposits in which depressions called *kettle holes* were left. Glaciers may act as dams themselves, and some large temporary lakes resulted from this cause, for example, glacial Lake Agassiz in the Red River Valley of the North, and glacial Lake Maumee in northern Ohio. Some lakes are located in natural basins as the result of earth movements. Examples include the Caspian Sea, Lake Baikal, and Lake Okeechobee. Solution of limestone by ground water has formed many ponds in the resulting sinkholes; these are found in northern Florida, central Indiana, and near the head of the Adriatic Sea. River changes on the flood plains sometimes form oxbow lakes; there are also delta lakes and others resulting from vagaries of deposition. Bars along a coast may cut off part of a bay or shore line, thus forming a lagoon.

A lake is a temporary geographic feature. No sooner has a lake been formed than forces begin to destroy it. The principal forces that destroy lakes are erosion of the outlet; filling of the bottom with sediment and vegetation; and the loss of tributary water by evaporation, use, or removal elsewhere. Salt lakes have no outlet, and those in deserts are caused by the concentration of the salt in the inflowing water that contains the mineral in small amounts. Other lakes may have been salt

originally and may have resulted from the separation of a portion of the ocean by land. Temporary wet-weather lakes in deserts of the United States are called *playas*. The existence of former lakes can be proved by the presence of lake terraces, old beach lines, and deposits once made in water but now located on the land. Lakes are used for water supply of cities, for health and pleasure resorts, for the storage of water for power and irrigation, for navigation in the case of large lakes, and as a source of food supply in their fish life.

Floods

Floods may constitute one of the greatest disasters of nature. Partly as a result of human activities, floods seem to be increasing in frequency and in damage. They are especially destructive in broad flood plains and level deltas, which because of their natural fertility are densely populated, sometimes supporting more than a thousand people per square mile. Floods from the Yellow River in northern China and on the Yangtze Kiang in central China have rendered tens of millions of people homeless and caused the deaths of hundreds of thousands—perhaps millions—of persons from starvation by the drowning out of crops. The U.S. Weather Bureau estimates that the average damage done by floods in the United States totals 35 million dollars per year. Great floods may exceed the average destruction, like that in the Mississippi Valley in 1927, which did more than 280 million dollars in damage, or that on the Ohio in 1937, when the river rose 87 feet at Louisville and ruined scores of millions of dollars' worth of property. In the spring of 1938, floods in the neighborhood of Los Angeles (where there are no large permanent rivers) destroyed property estimated at 65 million dollars (Fig. 224) and caused the deaths of more than a hundred people.

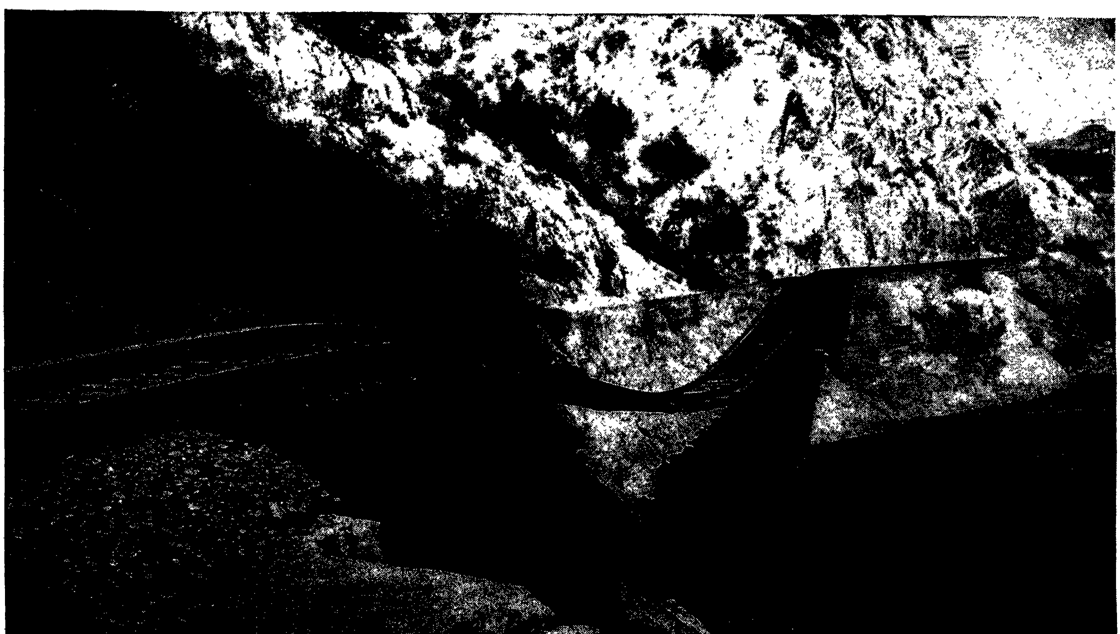

FIG. 224. Damage to transportation facilities caused by torrential rains and floods in southern California, March, 1938. The hills of this semiarid region have scant vegetation cover to prevent rapid runoff of surplus water. (*Photograph by J. H. Dyer, Southern Pacific Company, used by permission of the U.S. Weather Bureau.*)

Causes of Floods. Many factors may affect the runoff and contribute to the formation of flood conditions. Sometimes a single cause is the obvious explanation, but more frequently numerous causes unite to make a flood. Among the physical conditions affecting runoff are amount and character of precipitation; rate of melting of snow; the character of the natural vegetation; the topography, including the shape of the drainage basin; the character of soils and bedrock; and other geographical details. The total amount of rainfall is of less importance than the amount in a given time. Local floods result from intense storms that may produce several inches of rain in a few hours. These cloudbursts are common features of the rainfall in western mountains and plateaus of America. Even deserts may experience local thunderstorms that lead to floods.

Great floods, like those in the northeastern United States in 1936, the Mississippi flood in 1927, and the California disaster of 1938, all resulted from prolonged heavy rains, following a previous wet season that had already made the ground thoroughly soaked. When more rain fell, it could not sink in and be absorbed by the ground; instead it was forced to run off the surface, no matter how well forested the region was. From 1 to 2 feet of rainfall have been known to fall in less than a week, as a result of a series of cyclonic storms closely following each other along the same path or of a storm's becoming localized in a particular watershed and remaining there for several consecutive days instead of moving in its usual easterly direction.

Although great floods may come in forested regions when the litter under the trees and the soil itself become thoroughly soaked, runoff from bare mountain slopes is much more rapid than when a natural vegetation cover exists. In southern California, adjacent watersheds that had the same rainfall and relief features, but only one of which was covered by grass, showed marked differences in the amount of runoff. Heavy rainfall on the barren burned-over watershed produced floods that brought extensive damage and left enormous quantities of coarse gravel and boulders dumped over the fertile alluvial soil. The same rainfall on the watershed that was undamaged by fire did no harm, since more water sank into the ground and the runoff was slower. In Utah and the Colorado Plateau country, damaging floods have resulted from the destruction of natural vegetation by overgrazing. If large areas of ground are underlain by highly pervious material, like recent lava flows or very coarse gravel deposits, floods seldom occur because the water sinks into the ground almost as soon as it falls. Even pervious soil, if frozen, however, may allow rapidly melting snow to run off and cause local flood conditions. The great Columbia River flood in 1948 was partly caused by this factor.

Human factors may help to produce floods. In addition to destruction of natural vegetation by fires, overgrazing, and cultivation of the ground, men may encroach upon stream channels with bridges, buildings, walls, or levees until the stream in high water has insufficient channel to carry the flow. Again the drainage of swamps and lakes, which formerly served as regulators of flow, will allow more rapid runoff. Most large rivers, at least in their lower courses, flow across flood plains that are covered by water when the great floods occur, usually at intervals of many years.

Fertile flood plains are oftentimes reclaimed for agriculture by the building of embankments or levees to keep areas from being covered by water at flood stages. As long as only a few men reclaimed farms in this way, little harm resulted; but, when a whole flood plain was thus protected by high levees, trouble began. The levees restrained the flow of water during ordinary floods, but the great floods that come a few times each century are often too high for the limited room left for a water channel, and the rivers therefore overtopped or broke through the levees and did vast damage. The Yellow River of China, the Po River of northern Italy, the San Joaquin and Sacramento delta region in California, and parts

of the lower Mississippi flood plain have such high natural or artificial levees that the rivers literally flow above the surrounding land, and enormous areas are subject to flooding when a break occurs.

Control of Floods. How can flood damage be lessened? Some factors like the amount and intensity of rainfall are obviously beyond man's control; but, where human factors help produce floods, such errors may be corrected. The control of great floods like those on the Mississippi is a national problem because the damaging floodwater may come from distant states. Reforestation, the building of reservoirs to retard and store floodwaters, the moving of levees back from the riverbank so as to allow more temporary floodwater basins, and the removal of encroachments on the stream are all helpful. After the great floods of 1913, control dams and other devices were installed to check the floodwaters of the Miami and Scioto, tributaries of the Ohio River. More recently, flood-control measures have been instituted in the Muskingum watershed and on other streams, for the purpose of preventing flood damage within the river basins themselves as well as reducing the flood danger within the Ohio River Valley (Fig. 225). One control measure that seems to work with some success is the construction of spillways or floodways on the lower courses of rivers; these serve as by-passes to allow some of the floodwater to reach the sea by routes other than the main river channel (Fig. 226). Most of the lower Sacramento Valley is covered with flood-control devices of this type. After the great flood of 1927 on the Mississippi, the Federal government spent much money on flood prevention along the river and its tributaries. The new levees and spillways to the Gulf of Mexico showed their worth in 1937 when serious floods in the Ohio Valley were handled by the lower Mississippi without important damage to the latter area.

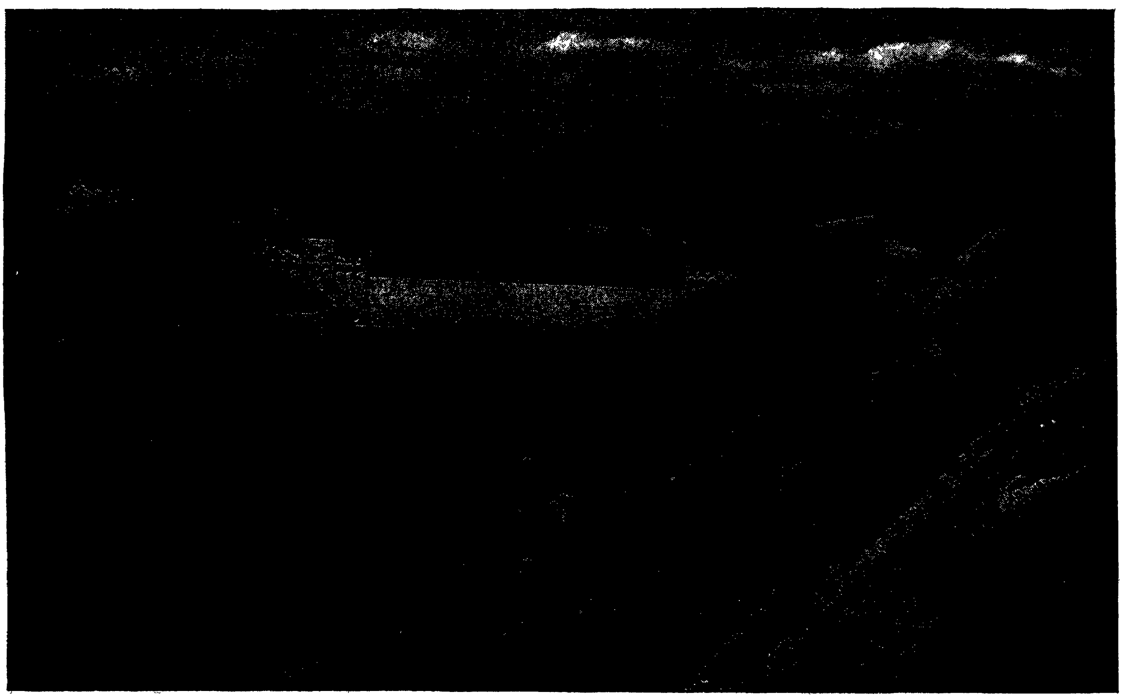

Fig. 225. Dover dam, near New Philadelphia, Ohio, built for flood control in 1938 to keep the Tuscarawas River from damaging farm land and other property in its lower reaches. The Muskingum Valley and its tributary valleys have fourteen dams constructed for purposes of retarding floodwaters. *(Photograph courtesy of the U.S. Soil Conservation Service, Department of Agriculture.)*

Swamp Drainage. Some land is covered with water in time of flood; it may also be far too wet most of the time to allow profitable farming until it has been drained. Much of the farm land of the Netherlands lies below sea level and has been reclaimed from coastal swamps bordering the North Sea or the bed of the Zuider Zee, a shallow salt-water lake or bay. Low wet meadows in England and in Germany have likewise been reclaimed for farming.

In the United States, Florida and Louisiana have the largest areas of swampland, but swamps are common all along the Gulf and South Atlantic coasts; Virginia has a large extent of swamp in the Dismal Swamp, and Georgia has its Okefenokee Swamp. The delta lands of the San Joaquin and Sacramento rivers in California required extensive drainage and diking to protect them against floods. Some flood plains along the Mississippi and other rivers require drainage. Many swamps are found in glaciated sections of the northern United States, especially in the states bordering the Great Lakes.

Some drained swampland is highly fertile and is now in productive farms (Fig. 149), but not all swamps are underlain by good soil. Before drainage, the soil of swamps should be investigated, because some swamps are worth more in a state of nature for hunting ducks, trapping muskrats, and cutting timber than for farms. Some swamps are underlain by peat, which is combustible after the land has been drained. In such cases, great care should be used to prevent the starting of peat fires, which in some places have done damage, as in parts of the Everglades of Florida.

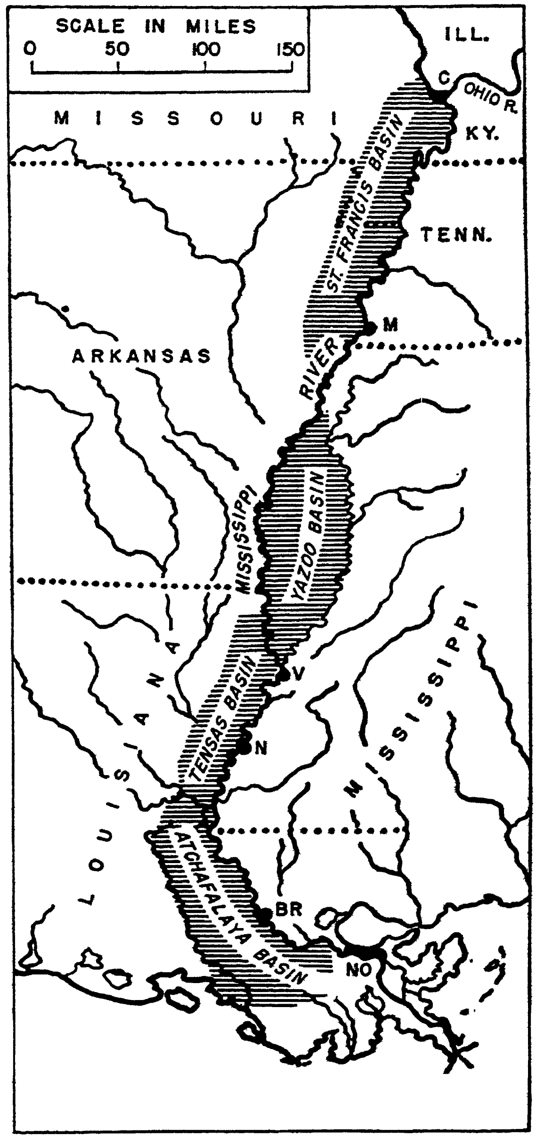

FIG. 226. Principal overflow basins on the lower Mississippi River. *C*, Cairo; *M*, Memphis; *V*, Vicksburg; *N*, Natchez; *BR*, Baton Rouge; *NO*, New Orleans.

Irrigation

In deserts the supply of water is the most important factor affecting the distribution of population and land utilization. Without water, no desert can be reclaimed. After satisfying the demands of desert dwellers for water for their personal use and that of their livestock, irrigation forms the next most important use of water, ranking ahead of power or transportation. In the Murray River region of Australia, for example, irrigation has so reduced the depth and flow of the river that its use by boats has declined. Since practically

all the water of the Colorado River is now used for irrigation or municipal supply, that stream no longer contributes an appreciable flow into the Gulf of California, and its former mouth has been replaced by a mud flat.

Early Development of Irrigation. Some of the earliest civilizations in the world were founded on irrigated farming, developed in river plains and in deserts. Success in raising crops by irrigation required cooperation, peace, and recognition of property rights so that individuals would reap the rewards of their efforts. The protection afforded by organized government permitted men to utilize their leisure time for cultural advances that led to the progressive development, improvement, and application of knowledge and other attributes of civilization. Great centers of civilization that evolved in this type of geographical setting include those of the Tigris-Euphrates flood plain of Iraq and the Nile civilization of Egypt. In irrigated areas today as in the past, there is great density of population and the exchange of ideas and knowledge is rapid and easy compared with the situation in mountains and other thinly peopled places. Unless very isolated from the world, like some oases in the interior of the Sahara, irrigated regions are among the most progressive farming areas in the world. It takes applied intelligence to carry on successful farming with irrigation.

Irrigation in Asia. Accurate statistics from China are lacking, but it is probable that India, with over 50 million acres, has more irrigated land than any country in the world. Although canals, mostly built by the government, have reclaimed over half the land, over 10 million acres are irrigated from wells and 7 million acres from "tanks," as small homemade reservoirs are called. The largest areas requiring irrigation in India are along the Indus River, in the upper Ganges Valley, and in the central part of the Deccan Peninsula. Water from tanks and wells may permit farmers to raise two staple crops per year, one supplied by the normal summer monsoon rains and a second by irrigation. The province of Madras claims nearly 70,000 tanks, most of which furnish water to only a few acres. In China the deltas and flood plains of the Yellow, Yangtze, and Si Kiang are a maze of canals and ditches used for transportation and irrigation of the rice fields.

The tilled land in Iraq, also called Mesopotamia ("between the rivers"), is irrigated from the Tigris and to a less extent from the Euphrates River. Without this water, the land would be a hopeless desert populated by a few nomadic herdsmen.

Irrigation in Egypt. Without the Nile, there would be no Egypt as we know it, where for over 6,000 years man has raised crops by irrigation. In early summer, torrential rains in the highlands of Ethiopia cause floods to descend on the Blue Nile and the Atbara. These waters reach Egypt by July and last through September. In Egypt a basin system of irrigation was developed early. The water is allowed to enter basins enclosed by dikes, where the water is retained until the ground is thoroughly soaked. Then the residue is drained away, and crops are planted in the mud, which contains enough moisture to mature the crop. Since ancient times, a little land for a second crop could be irrigated by pumping water from the river, often by hand methods. The British have helped reclaim more land by building a large dam at Aswan, the first cataract, to store water (Fig. 227). Four other dams downstream divert water into ditches for irrigation. Other works have been built in the delta, by which the area under crops has been materially increased and a million more people can be supported by farming.

Irrigation in the United States. In the United States over 20 million acres of crops are raised by irrigation methods, and over one billion dollars has been invested to put water on this land. The leading state is California, with nearly 5 million acres, followed by Colorado, Idaho, Montana, Utah, and Wyoming, all of which have over a million acres under irrigation. Other important states for irrigation are Arizona, Nebraska, Nevada, New

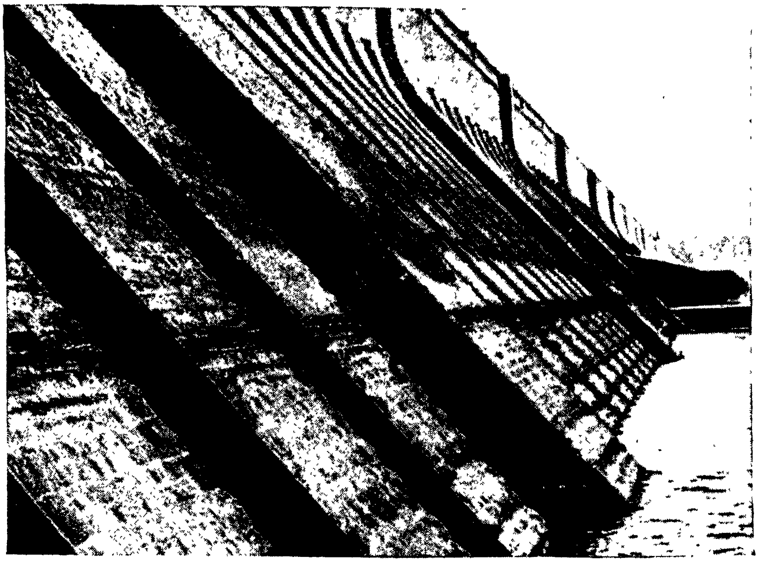

FIG. 227. Aswan dam on the Nile, in Egypt. The first control of the river was the construction of a barrage on the delta. This permitted the irrigation of the land through canals and its subsequent drainage. Thus Lower Egypt began to produce two or three crops each year instead of one. The great dam at Aswan was built under British direction, and water was made available to farm five-sixths of Egypt's arable acres throughout the year. (*Photograph used by permission of the British Information Service.*)

Mexico, Oregon, Texas, and Washington. The completion of the irrigation project in connection with the Grand Coulee dam in Washington will add over a million irrigated acres to that state's agricultural lands. Humid Arkansas and Louisiana have large areas under irrigation for growing rice, although land there requires drainage more often than irrigation.

Irrigation in America was begun on a small scale by Indians in Peru and Mexico and in a few parts of what is now the southwestern United States. The first large-scale application of irrigation by the whites was that of the Mormons, who began to reclaim desert land in Utah during the 1840's. Later other immigrants began irrigation in Colorado and California, and soon men were experimenting with the practice wherever arid land and supplies of water could be brought together.

Advantages of Irrigation. There are several obvious advantages of irrigation: (1) desert soil is unleached because of light rains and therefore contains abundant plant food, generally lacking only humus, which is readily supplied by legumes; (2) the water can be supplied as needed to the growing plants, and there is no dependence upon the vagaries of rainfall, which may come at the wrong time or in too great or too little amounts; (3) the large amount of sunshine in deserts favors production of quality fruits and other crops, and during harvest there is no danger of damage to the product from rain, as is often the case in humid lands; (4) the drying of fruit is simplified; (5) there are ideal conditions for farm work; (6) irrigation water sometimes carries silt in suspension, furnishing fertilizer to the soil; and (7) there is comparatively little damage from weeds and insects. The yield per acre under irrigation is high, resulting in dense populations and generally high conditions of culture and progressiveness (Fig. 202).

Irrigation Problems. Irrigation has its problems and disadvantages as well as its favorable aspects. Among geographic handicaps of irrigated regions are: (1) A tendency for alkali to accumulate in the low or poorly drained ground and ruin the soil for crop production;

this situation is sometimes relieved by flooding the ground to dissolve the salts and draining the water by tiling and ditches built for the purpose. (2) Heavy clay soils may become waterlogged and sour, especially if they are located at the center of a basin in which the flow of ground water is increased from excessive application of water on higher lands. Problems of this particular type have been faced by ranchers who attempt to farm the low ground along the western sides of the Sacramento and San Joaquin river valleys, and a similar problem has developed in the basin in which Mexico City is located. The remedy seems to lie in better drainage, and this may be expensive to install. (3) The very productivity of irrigated lands may be injurious to farmers by glutting available markets

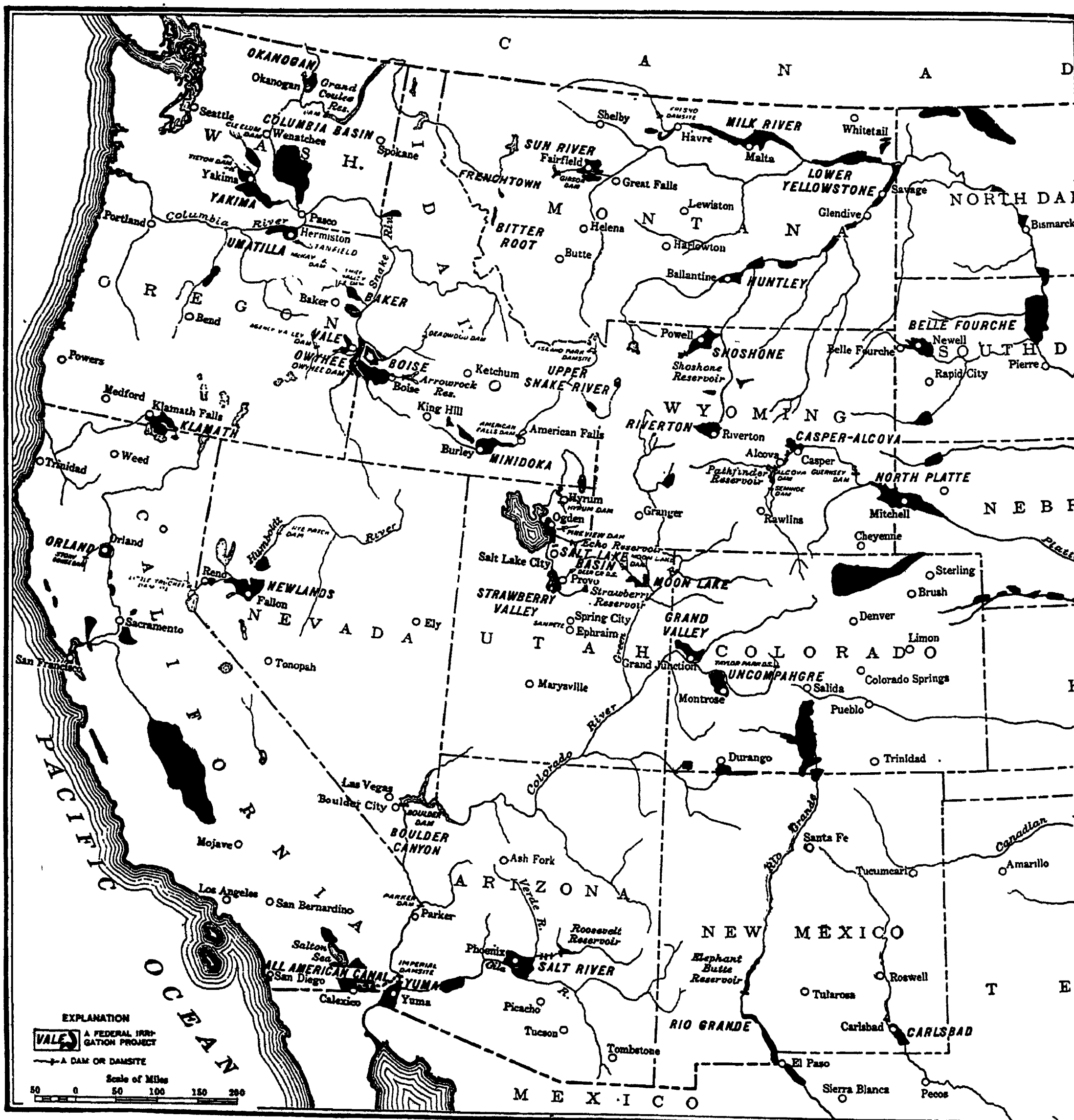

FIG. 228. Federal irrigation and power projects in western United States. Compare this with Fig. 123 and note the relationship with the national forests as sources of water. The name Boulder Dam was changed in 1948 to Hoover Dam.

with an oversupply of products, resulting in decreased prices as disastrous to farmers as crop failures. (4) Sometimes the supply of water is insufficient for the needs of crops, especially if its chief source is from the storage of floodwater.

On the whole, the advantages of irrigation much exceed its disadvantages; but experience is needed to succeed at irrigated farming, and some agricultural failures in this country have resulted from poor handling of land and water; poor judgment in crop selection; excessive cost of water, labor, and transportation; lack of capital; and speculatively high land prices. It takes several years to develop an irrigated tract so that it makes money for the owner. After many settlers on certain irrigation projects in the intermountain country had failed and abandoned their farms, a government survey showed that most of the failures had little capital and no experience with irrigated farming. Some had never farmed before, yet they undertook the hard task of developing raw land.

Irrigation Practices. Sources of irrigation water include the natural flow of rivers and creeks, reservoirs built for the purpose of storing water from winter snows and spring rains, and water pumped from underground sources. Occasionally natural lakes will provide water for irrigation, or the flow from a spring will provide a rancher with water supplies.

In the western states, water rights are recognized as a form of property, to be bought and sold. Men who wish to irrigate land file a claim on the natural flow of some stream, and the water is then supplied to the farmers in

FIG. 229. Grand Coulee dam on the Columbia River in Washington is a multiple-purpose structure. It is the largest power development in the world. When completed it will have 18 generators, capable of producing 144,000 horsepower each. Water will be lifted from Lake Franklin D. Roosevelt above the dam and will be used to irrigate more than a million acres in the Columbia Basin. (*Photograph courtesy of the U.S. Bureau of Reclamation, Department of the Interior.*)

the amount of the right and in the order in which filings were made. The usual way of calculating water flow in the West is by the miner's inch, an amount that varies according to the laws of the different states, or by the second-foot (1 cubic foot of water flowing each second). The acre-foot (1 acre of water 1 foot in depth) is used to describe the storage capacity of a reservoir.

Irrigation methods vary with conditions and crops. Pastures and meadows may be irrigated by flooding; row crops are watered by rills between the rows; artificial basins may be built and then flooded. Sprinkling is employed in some regions and for special types of crops. The water usually is carried to the irrigable land in open ditches, which are often lined with concrete and sometimes covered over to prevent excessive loss of water by evaporation. In some orchard districts and truck-farming areas the water may be distributed by pipes of wood, metal, or tile.

The amount of water that will be available for the irrigation season within a farming district is very important to the landowners. Careful studies are made of the amount of snowfall and its water content early each spring in the mountains that furnish the water supply to the district. These studies determine the amount of potential runoff of water so that plans can be made to use the available water to the best advantage.

Federal Reclamation Projects. In those places where conditions for reclamation of arid land were such that costs were beyond the ability of individual property owners to bear, the United States government has built about 30 irrigation projects in 15 western states since 1902 (Fig. 228). On these projects, thousands of families are supported on land that would be nothing but desert or a few scattered cattle ranches unless it had irrigation. Some of the storage reservoirs are held by dams that are among the largest on earth. The Grand Coulee Dam on the Columbia River is 4,300 feet long, 550 feet above bedrock, and contains 11,250,000 cubic yards of concrete. It impounds a lake, or reservoir, 150 miles in length (Figs. 229 and 256). The Hoover Dam on the Colorado River is the highest on earth, 727 feet above bedrock and capable of raising the level of the river 584 feet to create the world's largest artificial lake, Lake Mead. This reservoir is long and contains 30,500,000 acre-feet of water (Fig. 218). Hoover Dam will regulate the flow and prevent floods on the lower Colorado and will make possible the irrigation of parts of the Imperial Valley and other land. Ultimately it will supply 1,800,000 horsepower of electrical energy, some of which is used to pump water from the Colorado River to supply the city of Los Angeles, as previously described (Fig. 230).

Another large multiple-purpose dam has been built on the upper Sacramento River. Shasta dam is more than 500 feet high, and the reservoir behind it impounds water in amount exceeded only by the reservoirs of

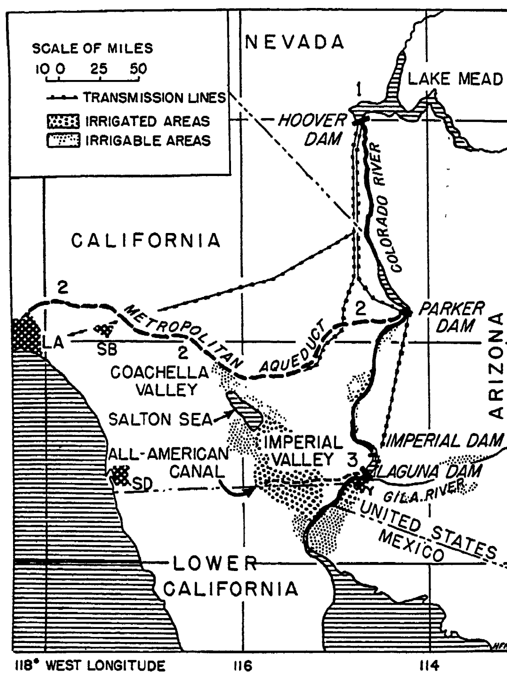

FIG. 230. Reclamation in the lower Colorado River basin. 1, flood control and generation of hydroelectric power at Hoover Dam; 2, urban water supply for coastal cities via Metropolitan Aqueduct; 3, flood control, urban and rural water supply by the All-American Canal. *LA*, Los Angeles; *SB*, San Bernardino; *SD*, San Diego; *Y*, Yuma.

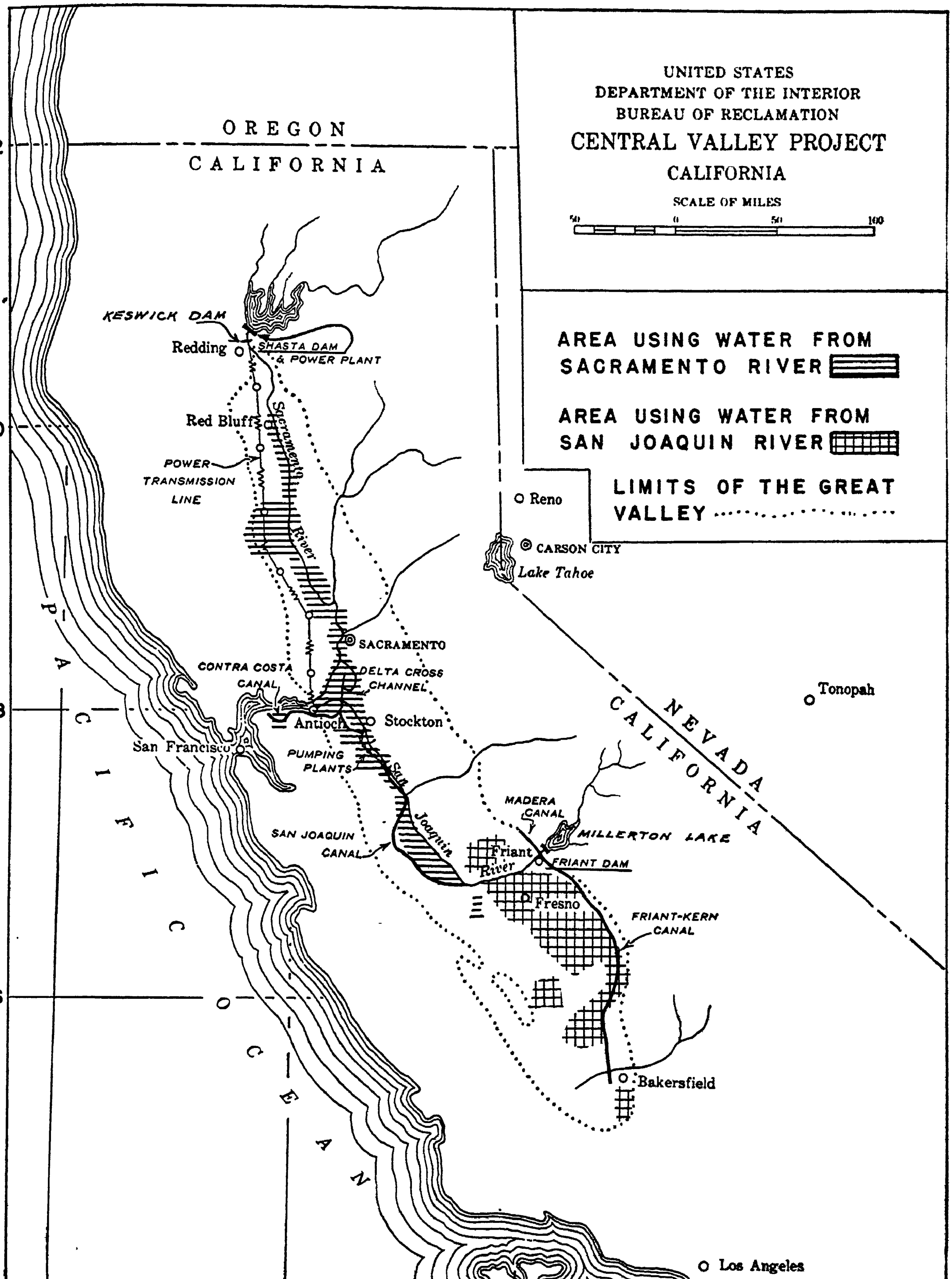

FIG. 231. Central Valley Project, California.

Hoover and Coulee dams. It impounds water to such an extent that the lake that is formed will eventually occupy canyons of the Pit and McCloud rivers. When this water is released during the dry summer, a 6-foot navigation channel is maintained in the Sacramento River for a distance of 90 miles upstream from the delta. Encroachment of salt water from San Francisco Bay is prevented, valuable delta farm lands will be reclaimed, and floods of dangerous proportions will no longer threaten the levee system of the lower river. Shasta Dam will generate sufficient power to pay for half the cost of the project, and much of the power will be used to pump surplus water from the Sacramento Valley onto the higher parts of the San Joaquin Valley, thus expanding the irrigated area in central California. Shasta Dam is only a part of a large plan whereby the Central Valley Project will serve as a major reclamation effort to improve farming conditions around Fresno and other parts of the Great Valley (Fig. 231).

Although not intended for irrigation, the Fort Peck dam near Glasgow, Montana, stores floodwaters of the Missouri River and so improves navigation on that stream. It is built of earth, over ½ mile thick at its base, nearly 4 miles long, and 240 feet high, containing 100,000,000 cubic yards of dirt. The Bureau of Reclamation completed 100 storage dams in the 17 western states from 1902 to 1946; in 1948 it had under construction some 14 storage dams and 11 reservoirs on various projects. The first of its dams for reclamation to be completed was the Shoshone Dam in Wyoming in 1910, which is 328 feet high; its height exceeds its length of only 200 feet at the top. The Roosevelt Dam on the Salt River Project in Arizona, the Elephant Butte Dam across the Rio Grande, and the Arrowrock Dam near Boise are among the important structures built by the United States government for purposes of storing water for irrigation. The Hungry Horse Dam, now under construction in Montana near Glacier National Park, will serve the dual purpose of supplying water for irrigation and electricity for power. Several of the dams built for irrigation have been paid for largely from the sale of power; this is true of the Roosevelt Dam in Arizona.

Problems

1. If there is a flood problem in your locality, tell what measures are needed to correct it.
2. How deep must wells be drilled in your locality to obtain water?
3. Why has the water table been lowered in most parts of the United States?
4. How is the subsurface flow of water in stream beds in the semiarid West utilized by farmers and ranchers?
5. How may surface waters be made potable?
6. What are the geographical conditions required for a satisfactory dam site?
7. Does stream pollution occur in your vicinity, and from what causes? Have measures been taken to correct this?
8. Discuss the transportation on the nearest navigable stream with which you are familiar.
9. The use of a river for commerce is influenced by depth, length, course, current, seasonal variation of flow, hinterland, and direction of flow. With these items in mind, account for the importance of the Rhine, the Yangtze, the Ganges, and the Amazon.
10. What continent has the largest supplies of potential water or hydroelectric power? What continent has the largest developed supplies of hydroelectric power?
11. Name three inventions that have made possible the use of large amounts of water power.
12. What part of the United States has the largest potential supplies of water power?
13. What is the distinction between water power and hydroelectric power?
14. Investigate the extent and character of drainage problems in your home neighborhood. How will drainage affect use of these wet lands?

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Note: The Federal Power Commission, Washington, D.C., publishes a number of items dealing with power resources. Soil Conservation Service, Washington, D.C., publishes various books and pamphlets on this subject. U.S. Bureau of Reclamation, Department of the Interior, Washington, D.C., issues many publications dealing with aspects of reclamation. U.S. Geological Survey, Department of the Interior, publishes a series of Water Supply Papers dealing with aspects of water power, floods, ground water, and other water resources. U.S. War Department, Annual Report of the Chief of Engineers, Washington, D.C., deals in part with the development of waterways, power sites, etc.

CHAPTER 21: *The Geographic Bases and General Distribution of Manufacturing*

Introduction. Manufacturing consists in the processing, fabrication, and combining of materials in order to make products with desired qualities, such as less weight, greater permanence, or increased usefulness. Among primitive peoples, most required articles were originally made in their entirety by individuals, and there was little division of labor. Indians, for example, manufactured articles of clothing from skins and hides; canoes from logs and bark; arrowheads, knives, and hatchets from stone; and pottery from clay. During the Middle Ages, most manufacturing was of the household and craftsman character. In colonial and pioneer America, small sawmills and gristmills were established early because they saved much hand labor and their output was in demand locally. Articles of clothing, tools, furniture, and simple household appliances were turned out in home factories by the family that needed them. Small streams were preferred by the pioneers for power with which to operate their sawmills and factories, since the energy required was not great, and development was relatively inexpensive and easily accomplished compared with that needed on large rivers. Under pioneer conditions, the first manufactures in great demand were necessities like sawed lumber, iron nails and tools, flour and meal, leather, knit goods of wool, and firearms.

The invention of laborsaving machinery and the use of steam engines for power led to the industrial revolution, the division of labor, and the development of the factory system and capitalism. Hand methods of manufacture could not compete with machinery, and the numerous and diverse types of home industry have for the most part disappeared from present-day economy. Today civilized man specializes, and large manufacturing establishments have been built to turn out quantities of a single product. Modern life, especially in the cities, is directly dependent upon manufacturing and the transportation and exchange of commodities. Our food, fuel, shelter, clothing, and conveniences of life depend upon industrial plants.

Integrated Industries. Some large corporations are integrated, from the production of raw material down to the wholesaling and even retailing of finished articles. A copper company, for example, mines and smelts the ore; refines the copper and recovers other metals as by-products; operates the railroad between mines and reduction works; manufactures sulphuric acid from the smelter fumes; uses the acid to make explosives and superphosphate fertilizer; produces its own coal; saws its own mine props and timber; and manufactures brass, copper wire, pipe, and sheet metals for the market. Petroleum companies operate their own oil wells, pipe lines, and refineries; make synthetic rubber and other chemicals; distribute the oil and gasoline in their own tank cars and trucks; and even control many retail outlets. A steel company may own mines, ships, and railroads and operate blast furnaces; steel mills; rolling mills; wire plants; sheet and tube mills; and plants making nails, rails, bridges, ship plates, and construction steel. A famous motorcar company owns iron mines, blast furnaces, steel mills, coal mines, sawmills, a glass factory, and a tire factory. It also manufactures plastics from soybeans, once controlled a rubber plantation, and operates fleets of ships and trucks to distribute automobile parts to assembly plants and finished cars to retailers. Chemical companies may manufacture thousands of different products.

Though the modern tendency is in the

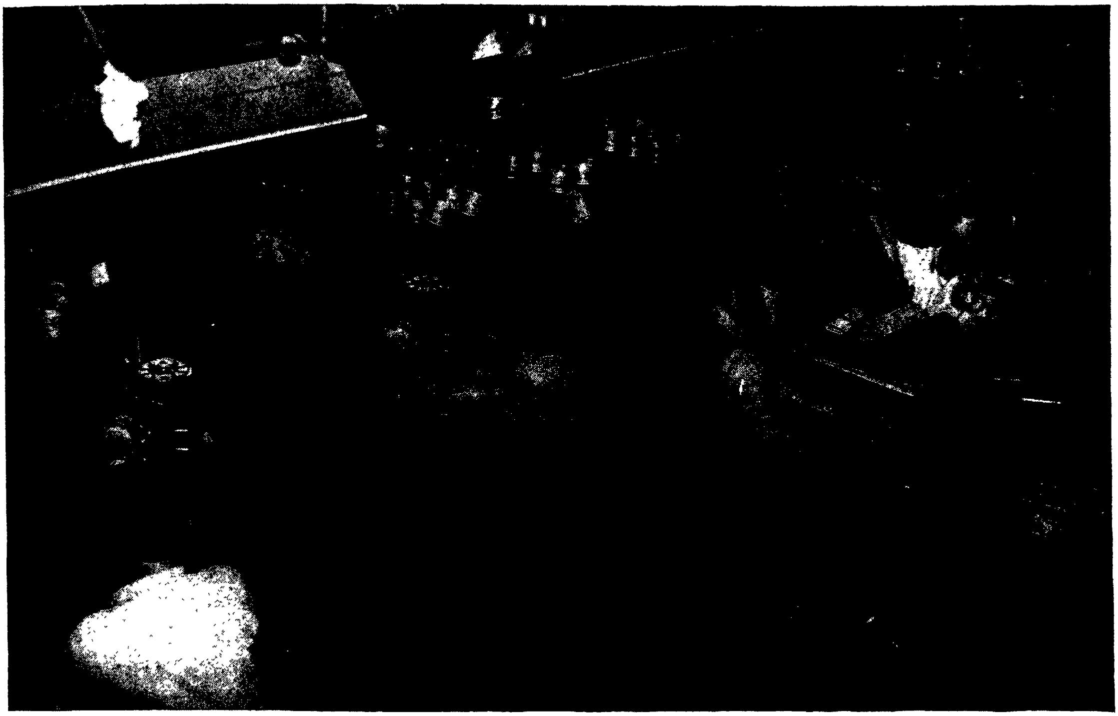

FIG. 232. Assembly-line manufacture of automobile engines near Detroit, Michigan. Workmen are fitting pistons into cylinder blocks. These intricate operations represent a high degree of industrial skill. (*Photograph used by permission of Ford News Bureau.*)

direction of large corporations that manufacture a variety of products and have branch plants throughout the country and abroad, there is also a place in our economy for the small plant, efficiently managed by its owner. A majority of the manufacturing establishments in the United States are of this nature.

The development of the assembly line (Fig. 232) and of machines that replace hand methods temporarily lessens the demand for labor; yet, because of reduced costs that result, the sales of articles sometimes increase to such a degree that the final effect is to employ as many laborers as ever.

Factors in Location of Manufacturing

The location of manufacturing activities depends upon various factors: accessible raw materials, power, markets, transportation, capital, labor, experience, inventions, and legislation. Though mills seem oftentimes to have been located by chance, it is probable that at least two or more of the above factors must be favorable; otherwise the concern will fail financially or cease to operate.

Raw Materials. Materials used in manufacturing may be of mineral, animal, or plant origin. Raw materials of large volume compared with the finished product are processed near the sources of supply in order to reduce freight charges in reaching the market. Examples include the concentration, reduction, and smelting of ores, extraction of sugar from beets and cane, sawing of lumber, and preparation of extracts like tannin from wood. The making of Portland cement, plaster, and clay products is done near sources of material, but it also depends on convenient markets because the products themselves are bulky and heavy. Perishable materials like soft

fruits, vegetables, milk, and fish must be processed near their points of production. The slaughter of livestock (40 per cent of a steer is nonedible) and the grinding of flour often occur between large producing and consuming areas, as at Minneapolis, Kansas City, Chicago, and Buffalo. By-products from these plants may be an additional source of income and may lead to the establishment of satellite factories that utilize them. Examples of factories depending upon surplus and waste products include glue and fertilizer plants in slaughtering centers and fish-meal plants near fish canneries. The manufacture of soap is often incidental to the meat-packing industry. Originally waste fat from animals was used in soap plants at Kansas City, Milwaukee, and Chicago, although Cincinnati and other places now depend principally on cottonseed and other plant oils.

The processing of raw materials accounts for the location and growth of many cities. Anaconda, Montana (Fig. 233), and Trail, British Columbia, are smelter towns. Bangor, Maine; Ottawa, Canada; Saginaw and Muskegon, Michigan; Longview, Washington; Klamath Falls, Oregon; and Eureka, California, are among the many sawmill centers of North America. Fish or shellfish processing helps to account for the location and growth of Astoria, Oregon; Gloucester, Massachusetts; Baltimore, Maryland; and Ketchikan, Alaska. The canning of fruits and vegetables is a specialty of California and the Middle Atlantic states, but Indiana leads in tomato canning, and Walla Walla, Washington, and other towns nearby are important for the canning of peas.

Sometimes conditions and factors that affect manufacturing change, sources of material are exhausted, new materials both raw and partly processed may become available, or market demands vary. These changes are reflected in the closing and opening of plants, modification of products manufactured, and in-

FIG. 233. Copper reduction works, Anaconda, Montana. *(Photograph courtesy of Anaconda Copper Mining Company.)*

crease or decrease in population of the affected communities.

Power in Relation to Manufacturing. There are many sources of power, as described in a previous chapter. Sometimes their use for manufacturing purposes is a comparatively simple thing; in Egypt and in China human beings and animals operate devices for lifting water, but in the United States the operation would be performed by windmills or engines. In the Netherlands windmills still grind some grain and pump water from the low ground (Fig. 161), though they have been largely replaced by more efficient engines. Water power operated the first mills in New England and determined the sites of many manufacturing centers, as at Holyoke, Lawrence, and Manchester. The growth of Passaic, Minneapolis, and Spokane has come partly from the presence of nearby waterfalls, as has also that of the cities along the fall line at the contact of the hard rocks of the Piedmont and the weaker strata of the coastal plain.

Near the end of the nineteenth century, hydroelectrical development and the long-distance transmission of power accelerated the growth of the cities that were located favorably with regard to falls. Power sites are usually found in narrow gorges where there is insufficient land for the construction of factories or homes for workmen. Now, with transmission of the power to points some distance from its origin, factories and towns may locate some distance away from the falls, on sites that are convenient and suitable for urban centers. While Grand Coulee dam was under construction, thousands of laborers were living in adjacent towns, but now only a fraction of the original number remains nearby; upon completion of the dam, tens of thousands of people living some distance away benefit from the hydroelectric power that is generated at the dam. Abundant power leads to the location of plants requiring vast blocks of energy; both aluminum and atomic-bomb plants were located in relation to Grand Coulee and Tennessee Valley hydroelectric power sources.

The principal fuels used for power are coal, petroleum, and natural gas. Wood is consumed in small installations usually remote from supplies of the mineral fuels. Sawdust and refuse from sugar mills are important in some places for boiler fuel.

The leading manufacturing regions of the world in western Europe and the northeastern United States are located near large coal resources. The manufacturing of the Pacific coast is run principally by petroleum and water power. Soviet Russia has several industrial districts that are favored by nearness of coal, oil, and water power. India and Japan have supplies of coal but not in sufficient quantities for their manufacturing needs. Coal alone is not enough to lead to manufactures; China, for example, has never made extensive use of its large coal deposits for industrial purposes.

Operations like the manufacture of iron and steel, consuming much coal for fuel as well as for power, usually are located near the coal mines or at points, like the shores of the Great Lakes, where coal and iron ore can conveniently meet, even if the iron ores must be shipped longer distances than the coal. Industries using little power compared with the value of their finished product, such as clothing, shoes, clocks, and small articles in general, prefer locations near markets and labor supply or at sites with established reputations for their product. In these cases, the cost of power is a minor factor.

Markets. Until transportation is available to world markets, the output of little mills would be limited by the small local markets. Where processing plants depend upon distant markets, a location near or on the seacoast is an advantage because of the low cost of ocean transport. It is economical, for example, to refine the petroleum from Venezuela on a nearby island, Curaçao, which has a good harbor to which the oil from the mainland is shipped in small shallow-draft tankers. Again, western Washington logs are usually

sawed into lumber at deep-water ports on Puget Sound rather than at interior points that are served only by rail and truck (Fig. 100). Seaports have advantages in using raw materials from distant sources to manufacture goods for reexport and distribution inland. Marseille manufactures soap and oleomargarine from tropical plant oils, and this industry is important in Los Angeles, San Francisco, New York, and other ports. New Orleans and San Francisco process and ship coffee, tea, and spices, as well as raw sugar. The smelting of tin ores at Swansea, Wales, is favored by nearness of coal supplies as well as the seaboard location.

The manufacture of heavy goods is done to greatest advantage near the consuming markets. Agricultural machinery manufactures are concentrated in the Middle West, among America's best farming lands. Heavy articles like pumps, dynamos, engines, tractors, railroad cars, hoists, mining machinery, cranes, and machines to make steel parts are made in Pennsylvania and near the lower Great Lakes (Fig. 234). Automobile parts are produced in scores of cities in Michigan, Ohio, Indiana, and Illinois, located conveniently with reference to assembly plants at Detroit, Flint, Toledo, South Bend, and other cities. Tire manufacture at Akron presents another example, although other factors—particularly an early start—are important in this case.

Perishable goods, like bakery products, obviously must be sold locally. Newspapers likewise have limited areas of circulation, and the trading area of a metropolis often is calculated from newspaper distribution. Cities are style centers, and the manufacture of clothing, jewelry, and the like is concentrated there.

Bulky building materials like brick, tile, sewer pipe, windows, doors, and cabinets are preferably manufactured near large cities or other densely populated regions. Mills shaping building stone, and cement and plaster plants turning out bulky and heavy products that are expensive to ship long distances suc-

FIG. 234. Tapping molten metal from a modern blast furnace. (*Photograph courtesy of Youngstown Sheet and Tube Corporation.*)

ceed near centers of population or other construction-material markets.

Transportation and Manufacturing. Transportation to markets is an essential factor in plant location. Heavy industries usually locate on railroads, along with cereal mills, meat-packing plants, paper mills, and woodworking factories, though navigable rivers, canals, lakes, and seacoasts are also sought. Light industries like textile manufacture, printing, and shoe manufacture are less dependent on rail transport, since their products are valuable rather than heavy and can stand the expense of trucking to freight depots. Commodities which are perishable or on which fast delivery is needed are usually manufactured in railroad centers from which lines diverge in all directions. Meat packing, bakeries, publishing houses, and mail-order concerns are advantageously located in Chicago. Certain products manufactured from imported materials are processed and manufactured in seaports for distribution inland and for sale abroad; for example, copper is smelted in Tacoma and bauxite is processed at Mobile.

Seaports may also process materials from the hinterlands for export; flour is made from Columbia Basin wheat, and lumber from the Cascade Ranges is made into furniture and other goods at Seattle. Petroleum products from inland oil fields are refined at Richmond, California, and at Philadelphia. The cost of freight is an important factor to consider in manufacturing at seaboard locations. Formerly freight rates were higher in the southern states than in the northeastern states, but a reduction in rates in the South has been achieved and may encourage additional manufacturing there. In general all manufacturing regions of the world—in the United States, western and central Europe, and Japan—are provided with adequate transportation. Without this, the receipt of fuel, raw materials, food for the workmen, and shipment of finished goods would be impossible.

The Need for Capital. Some manufacturing requires only a small investment, and the essential buildings and machinery are adapted to the abilities of individuals and cooperative associations of small means. Portable sawmills, neighborhood bakeries, community creameries and cheese factories, local printing plants, tailoring shops, and laundries are of this type, although large corporations also engage in output of the same articles on a large scale, and cooperatives sometimes manage fertilizer works, flour mills, and oil refineries. In contrast, those industries which require large investments, like heavy machinery, textiles, petroleum refineries, metals processing, sugar refining, chemicals, and shipbuilding, are carried on by large corporations or wealthy individuals. Long-settled regions and well-established cities usually have capital available for investment and can finance new industries and expansion of plants. Of course, the mills and factories are not always located in the area furnishing the capital, but that is more probable unless nearness to raw materials and special markets is especially desired.

In some countries industrial plants are located with regard to military and political purposes. Remoteness from attack, available labor supply, power, and materials are among the factors considered when governments control plant locations. To an increasing extent, corporations make intensive surveys before they decide on new plant sites, and their decision increases the chances for financial success if they have considered sound economic and geographic principles. Some rapidly growing communities like southern California have capital available from newcomers, part of which may go into new industries like airplane manufacture at Los Angeles and San Diego. A bonus given by a town to attract a manufacturing plant often fails to bring in the type of company that would benefit the community. On the other hand, a few thousand dollars induced a rubber company to move to Akron, thus beginning a concentration of rubber manufactures that led that city to become the tire capital of the world.

Labor for Manufacturing. A supply of labor will always be advantageous to industry;

for example, silk and rayon mills are common in the coal and iron centers of eastern Pennsylvania partly because these light industries employ many women, and the wives and daughters of the men who mine coal and work in the steel plants are available for factory labor. Labor is not so important today as formerly, however, because the use of labor-saving machinery in many mills has eliminated the need for many workers. Some manufacturers need seasonal labor; and if this is not available locally, it must be imported at increased expense. This situation is prevalent in the canning of fish, in the harvesting and canning of fruit and vegetables, and in some other industries.

Clothing is made for the most part in the larger cities because the factories use many employees in a small space; furthermore the industry is near metropolitan markets and style centers. Less craftsmanship is needed under mass production than by the hand methods used in the past. Textile mills that moved from New England to the southern Piedmont brought in only a skeleton force of keymen, who soon trained local laborers to operate the machines. Years of apprenticeship are not required of workmen on an assembly line—instead farm hands, city housewives, and recent immigrants can be trained in a short time to feed a machine, pull a lever, or perform a required task on the assembly line. Nevertheless skilled labor is an advantage, and newcomers to the manufacturing field may locate in a city important for the article to be manufactured; thus the laborers employed are already experienced. The making of accurate machines, typewriters, rifles, locks, watches, and other small metal articles is a specialty of Bridgeport, Hartford, Springfield, and other New England towns. A famous inventor of machine guns lived in Utah, but the weapons were manufactured in the Connecticut Valley.

Invention, Early Start, and Reputation. Many manufacturing establishments are in their present-day locations because of the accidental residence there of an inventor whose ideas were expanded into a large industry, or possibly the arrival of an immigrant having special skills and salesmanship led to the beginnings of industry. Among industries whose locations reflect the homes of inventors are the manufacture of automobiles or motor parts in Detroit, Indianapolis, and Cleveland; breakfast foods in Battle Creek, Michigan; adding machines and airplanes in Dayton, Ohio; cameras and film in Rochester, New York; and household games in Salem, Massachusetts. Many large mills and factories began in a small way and after long years in their original location have accumulated good will and reputation of the utmost value. This is true of optical goods made in Southbridge, Massachusetts; lodge emblems in Attleboro, Massachusetts; flour and cereals in Minneapolis; tires in Akron; hats in Danbury, Connecticut; and watches in Waltham, Massachusetts.

When corporations have large investments in a certain location, an industry tends to remain there, though some other site might be preferred if the company were beginning operations. Pittsburgh with its iron and steel industry is a good example of this type of industrial inertia. Of course, if the original site is a real handicap, even large concerns may move, as did the Lackawanna Steel Company from eastern Pennsylvania to Buffalo, and textile mills from the Merrimac Valley to the Piedmont. Plants are sometimes kept in the home town by an owner for personal and sentimental reasons.

Reputation for design may attract persons to a city who are interested in a particular line of goods; they may be buyers or manufacturers. This is the case with clothes designing in Paris, New York, and London; but the Hollywood stylist is also important, particularly in the lines of women's sport clothes. Furniture styles that evolve in Grand Rapids, Michigan, are popular in this country. New York, Paris, and Amsterdam are centers of jewelry design; and precision machines are manufactured in Switzerland, Germany, and

the Connecticut Valley. These places often govern the styles in their respective lines.

Government and the Manufacturing Industries. Governments may exert marked influences upon manufacturing, by their use of protective tariffs, import quotas, currency controls, exchange of finished goods for raw materials, loans, bonuses for export, and other practices. In order to favor the employment of American laborers, the tariff on raw materials generally is less than on the finished goods. This encourages the refining of sugar and metals in this country and the manufacture of cigars from imported leaf tobacco.

With the aid of their government during the decade from 1930 to 1940, Japanese industrialists were enabled to "dump" cottons, toys, electric light globes, and many other articles below the cost of production in other countries, thus competing with the manufactures that entailed a higher production cost. Japanese shipments of cheap ceramic wares, for example, nearly put some of the American potteries out of business because of the difference in production costs in the two nations. Prewar Germany followed the policy of buying quantities of foodstuffs and raw materials but requiring the purchase of certain manufactured goods that the other country did not need in return. Germany also paid for her imports with currency that could not be removed from the country and had to be spent within Germany. To protect their own industries, nations suffering from dumping of goods may place a quota on imports from those nations which pursue such policies. Free trade and the law of supply and demand in theory will promote the production of goods where it can be done most efficiently and economically, but in practice nations continually interfere with the natural flow of goods.

For strategic reasons of self-sufficiency in war, Germany, Japan, and other states built and operated plants at a loss in order to have key industries available when they were needed in wartime. Armament, chemicals, aircraft, synthetic gasoline and rubber, and other commodities are among these essential manufactures.

World Distribution of Manufacturing

Many of the most densely populated areas of the world are the result of the concentration of manufacturing activities, and for many years it has been apparent that increase of manufacturing has been accompanied by the growth of cities. The principal causes that contribute to the geographical location of manufacturing districts have been discussed; obviously these causes must be exceptionally favorable where our most important industrialized regions are found.

United States and Canada. The most important manufacturing region in North America extends westward in a broad belt from the Atlantic coast between southern Maine and Chesapeake Bay as far as St. Louis and the twin cities of Minneapolis and St. Paul. It includes southern Michigan, peninsular Ontario, and the St. Lawrence Valley as far downriver as Montreal, but it excludes some rural regions like the Adirondacks. Within this American manufacturing belt (Fig. 235), there is a considerable degree of specialization in manufactures.

New England is favored by abundant water power and raw materials obtainable from her forests; but this part of the country lacks supplies of iron ore, coal, and petroleum. Coal is brought from the Appalachian fields, and the import of petroleum products and raw materials for manufacture (cotton, wool, hides, and the like) is favored by New England's seaboard location. Traditionally New England is important for its textile mills and metal-fabricating establishments. Textile manufactures are concentrated in the Merrimac Valley of Massachusetts near the cities of Lowell and Lawrence, and in New Hampshire at Manchester, Concord, and Nashua. Another section famous for its textiles is the Blackstone

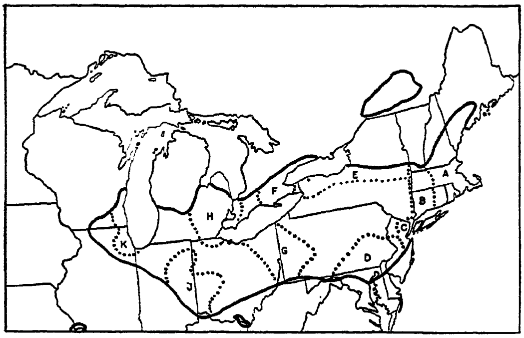

FIG. 235. Manufacturing belt of the United States and Canada. (*After R. Hartshorne.*) *A,* Eastern New England, differentiated light manufactures; *B,* southwestern New England, light manufactures with emphasis on metal products; *C,* New York district, secondary manufacturing; *D,* southeastern Pennsylvania, light and heavy manufactures; *E,* Mohawk Valley, secondary manufacturing specialties; *F,* Ontario region, light and heavy manufactures; *G,* Pittsburgh-Cleveland region, heavy industries; *H,* southeastern Michigan area, specialized manufacturing; *J,* Ohio-Indiana region with diversified metal industries; *K,* Lake Michigan district, heavy industries with some secondary industry. [*Used by permission of Richard Hartshorne; adapted from A New Map of the Manufacturing Belt of North America, Economic Geography, 12: 43–53 (January, 1936).*]

Valley, between Worcester and Providence; still another centers around Narragansett Bay at New Bedford and Fall River. Competition from other areas, particularly the Appalachian Piedmont, has caused some decrease in cotton-textile manufacturing in New England, but the production of woolens has been little affected.

The fabrication of metal products requiring skill rather than weight of material, such as hardware, tools, firearms, and electrical supplies, is a manufacturing specialty of the Connecticut Valley, particularly in the cities of New Haven, Hartford, and Springfield. Paper manufacture at Holyoke, Massachusetts, and in some towns in Maine; machinery of many types; clothing; and publishing are typical industrial activities of New England. The manufacture of shoes and other leather goods is important in eastern Massachusetts at Haverhill, Lynn, and Brockton; optical goods, watches, clocks, and hundreds of small items are products of New England's mills and factories.

The *Middle Atlantic* manufacturing centers are divided in two main groups: those located near or on the coast, and those occupying inland sites. The important coastal nuclei include the large cities of New York, Philadelphia, and Baltimore with their affiliated satellite cities and metropolitan areas. These three large port cities process many imported raw materials for local use and for shipment both inland and abroad. New York, for example, imports both cotton and woolen yard goods from New England mills and fabricates the material into finished articles of clothing, and this city is the center of the American clothing trades. The city also serves as a center for many of the publishing houses of national scope. Washington, D.C., has little manufacturing activity compared with other cities of equal population in this country, although its printing and publishing business is well developed.

An advantage of this seaboard area is the ease with which coal is secured from the Appalachian fields by rail, and petroleum by pipe line and ocean tanker. Much iron and steel is manufactured in eastern Pennsylvania and near Baltimore. Ships, locomotives, electrical equipment, chemicals, and small metal goods are made near Philadelphia. Baltimore is famous too for its airplane plants; and Wilmington, Delaware, is an important center for the manufacture of explosives. The cities of eastern New Jersey that are tributary to New York carry on the refining of oil and the processing of metals and foodstuffs. Leather goods is an important industry in southeastern Pennsylvania and in southern New York, with towns in the vicinity of Binghamton, New York, making quantities of shoes. The seaboard manufactures a great variety of other products too numerous to itemize.

A well-industrialized zone extends across upper New York State from Albany to Rochester along the line of the New York Barge Canal and several main railroad lines that traverse this low corridor connecting the Hud-

son River and Lake Erie. Schenectady, Syracuse, and Utica are manufacturing centers within this zone. Textiles, clothing, chemicals, photographic supplies (at Rochester particularly), metalwares, electrical and other types of machinery, paper, and scientific instruments are among the goods produced in this part of the manufacturing belt.

In western Pennsylvania and in West Virginia, the cities and the mills are located in the stream valley bottoms; they obtain such raw materials as coal, oil, limestone, and other needs from the adjoining hills of the plateau. The making of iron and steel, and its use for the manufacture of all types of machinery, pipe, structural steel, and other products, is the leading industry. Chemicals, cement, clay products, petroleum refining, and glass making occupy many people. Pittsburgh is the leading city, although there are many other centers of heavy industry, including Charleston, Wheeling, and Huntington, West Virginia. Scores of industrial towns and cities lie within the Pittsburgh district, with Youngstown (Fig. 236), Massillon, and Canton, Ohio, on its periphery, where the influence of Cleveland's activities is felt to a degree.

The *Southern Great Lakes* district is one of the most important manufacturing districts in the nation. Here coal brought by rail from the interior meets iron ore, lumber, and grain brought in by ship down the lakes. The zone continues along both shores of Lake Ontario and for some distance down the St. Lawrence;

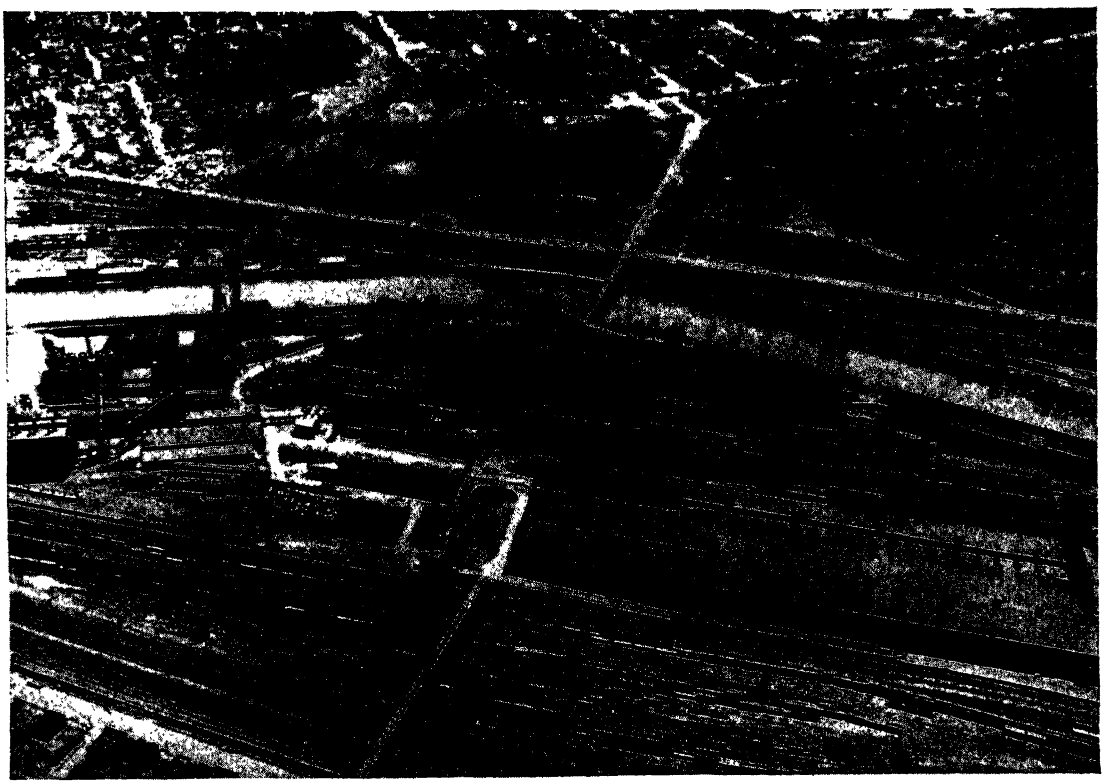

FIG. 236. Part of the Campbell works of the Youngstown Sheet and Tube Company, Youngstown, Ohio. Two blast furnaces and part of the stock pile for iron ore appear at upper left; open hearth mill is in center. Note sharp division between use of industrial land in foreground and residential property in distance. Note also the intensification of rail lines in foreground; these bring coal and iron ore to Youngstown. (*Photograph courtesy of the Youngstown Vindicator.*)

it includes some inland areas that are tributary to the lakes. Some of its industrial centers, like Gary, Cleveland, and Buffalo, specialize on the production of iron and steel goods. These cities, with others like Chicago, Milwaukee, Racine, Detroit, Toledo, and Toronto, manufacture machinery and a wide assortment of iron articles. Detroit and other southern Michigan cities, notably Flint and Pontiac, lead in the manufacture of motor vehicles, an industry that is likewise important in Cleveland, South Bend, and many other centers. Akron, Ohio, specializes in the manufacture of rubber articles. Shipbuilding, tractors, railroad cars, paint, furniture, paper, clothing, chemicals, agricultural implements, clay products (Fig. 237), and publishing are important within this part of the industrial zone, and many of these goods are specialties of Chicago factories. The manufacture of flour, and the processing of meat, fruits and vegetables, corn and soybean products, and many other types of economic activity within this region depend upon the abundance of farm products, some of which come from local origins and some of which are shipped in from western states.

The *Ohio and Upper Mississippi valleys* include the river towns, and inland centers like Indianapolis, Columbus, and Dayton. Cincinnati, Evansville, and Louisville on the Ohio and St. Louis, Rock Island, Moline, Davenport, and the twin cities of Minneapolis and St. Paul are important cities on the Mississippi. Fuel is near at hand except for the Twin Cities, and many materials are available for manufacture, including farm products, timber, iron, lead and zinc, and clay and stone. The region is near the center of population of the country, is well supplied with rail transportation, and is near large numbers of potential and actual customers. Metalworking, chemicals, shoes, meat packing, clothing, furniture, automobile parts, and the fabrication of many types of machines are among the

FIG. 237. Manufacturing clay products in an Ohio ceramics plant. Here the plates are separated by clay pins and placed in receptacles in which they receive their final firing in the kilns.

important industries of this region. The processing of foodstuffs is particularly important.

The westernmost part of this industrial zone extends to Kansas City and Omaha, Nebraska, and Wichita, Kansas, where meat packing, flour milling (Fig. 254), oil refining, and car shops are among the important economic activities, with Wichita a center for the manufacture of airplanes.

The *South* has made great advances in its manufacturing during the present century. The Piedmont area extending from Virginia through the Carolinas into Georgia has become a leading center of cotton and rayon textiles manufacture, with Greenville, South Carolina, claiming to make more cotton cloth than any other city in the United States. Cheap and plentiful hydroelectric power and relatively low-cost labor are two principal advantages of the Piedmont district. Cigarette manufacture is a specialty of Durham and Winston-Salem, North Carolina. Farther south, Birmingham, Alabama, with its coal and iron ore supplies near each other, manufactures much iron and steel. Atlanta, Georgia, and the Tennessee cities of Nashville, Memphis, Chattanooga, and Knoxville are gaining in importance. Electric power from the dams installed on the Tennessee Valley Authority project has been a factor in smelting aluminum and in the development of various chemical industries. Timber and raw cotton, with supplies of water power or coal near at hand, are important industrial advantages here. Savannah, Georgia; Jacksonville, Florida, and other coastal cities of the South depend on the forests for their output of lumber, paper, and ships stores.

New Orleans and Baton Rouge in Louisiana; Houston, Texas, and the cities along the coast of that state are important in the refining of petroleum and in the manufacture of chemicals; they are also increasing their processing of food products and their general manufactures. Inland, Fort Worth, Dallas, and Oklahoma City are among the growing cities that process the products of the farms and ranches and have profited from the wealth of the Mid-Continent petroleum field.

The *West Coast* is of growing industrial importance, though it lacks some of the essentials that have contributed to the success of industry in other parts of the country. Aircraft manufacture is especially important at San Diego, Los Angeles and its surrounding communities, and Seattle. In the Los Angeles and San Francisco areas, petroleum refining, shipbuilding, clothing manufacture, home furnishings, publishing, and food processing are important activities. Hollywood is world famous for its motion pictures. The Northwest cities of Portland, Oregon; Seattle and Tacoma, Washington; and Vancouver, British Columbia, are traditionally important in the lumber, paper, and fishing industries of that section; but they have begun to expand along many lines of general manufacture. Cheap hydroelectric power is encouraging the growth of the aluminum industry, steel making, and the manufacture of chemicals.

European Industrial Areas. Europe is the most highly industrialized continent—the result of a combination of circumstances that include its early start, its skilled labor, its available power and raw materials, and especially its coal and iron. Furthermore the continent is accessible for trade, enjoys types of climate favorable for industrial activity, and has a large local market in its population. Inventions and factory methods used during the industrial revolution were first applied in European industry.

The heavy industries of Europe depend on coal and iron, and the location of these essentials described in the preceding chapter accounts for the concentration of coal mines, blast furnaces, steel mills, and machinery manufacture in Great Britain, the Ruhr Valley of western Germany, northern France, Belgium, southwestern Poland, Czechoslovakia and Saxony, the Donetz Basin, Moscow, and the southern Ural regions of the U.S.S.R. Chemical industries often accompany heavy industry. Many of the light industries, such as clothing manufacture, publishing, food

processing, and drug manufacture, are located in the cities.

Among *England's* centers of industry are the Midlands region near Birmingham and Sheffield in the north, which is important for machinery, vehicles, hardware, munitions, chemicals, glass, and numerous small articles. London must import its coal but is a great manufacturing center nevertheless; its industries include clothing, publishing, soap, food processing, and chemicals. Northeast England at Newcastle and other towns manufactures iron and steel into machinery, ships, and cars, and makes chemicals from its salt and coal. Western England leads in the weaving of cotton textiles at cities like Manchester, Preston, Bolton, Blackburn, and Oldham. In these centers, coal for fuel was readily available, and spinning and weaving received an early start, as well as the manufacture of machinery needed for this type of undertaking. The port of Liverpool on the west coast maintains much ocean traffic with America, from whence come raw cotton, grain, and meat, all needed in this industrial area. Woolens are a specialty manufacture of the Yorkshire district, which obtained its supply of raw material from the nearby Pennine Hills. Leeds, Bradford, and Halifax also manufacture woolen goods. The principal manufacturing area in Scotland includes the city of Glasgow, famed for its shipbuilding, machinery, and textiles of cotton, wool, linen, and jute. Belfast in northern Ireland also is a shipbuilding center and a source of linen manufactures.

The manufacturing industries of *France* are located principally in the northern and northeastern part of the country, where coal and iron ore are at hand. This industrial district extends into Belgium and the Saar Basin on the north and east and connects with the Ruhr Valley in Germany. In France, the cities of Valenciennes, Lille, and Nancy are large centers of textile manufacture; the Belgian cities devoted to this industry include Namur, Liége, Brussels, and the port of Antwerp. These centers also are engaged in heavy and light industry, including iron manufactures, chemicals, and food processing. Paris is world famous for designing and manufacturing clothing, millinery, and other luxury goods. Lyon in the Rhone Valley makes silk fabrics, automotive equipment, and fine soaps.

The Ruhr Valley (Fig. 238) is *Germany's* leading industrial area, largely because of its rich coal deposits. Essen, Dortmund, and Bochum lead in heavy industry and formerly led in munitions manufacture. In Duisburg, Cologne, and a dozen other large cities of the area, light metalwares were made, including hardware and firearms; other activities were directed toward the weaving of textiles and the manufacture of chemicals, cement, and many other products and items. Berlin, Munich, and Hamburg were important for their general industries. In Saxony, textiles were extensively manufactured. Leipzig was famous as a publishing center and Dresden for its porcelain. In Silesia, which is now incorporated within Poland, there are deposits of coal, iron, and zinc, and Breslau was the largest manufacturing center.

Czechoslovakia is fortunate in having a variety of resources, including coal, and this nation is important for its manufactures of both heavy and light metal goods. Vienna, Austria, and Budapest, Hungary, are large cities having some light industry, but they are now handicapped by the loss of some of their former trade territory.

Southern Europe has scattered industrial centers, most important of which is in northern Italy with its cities of Milan, Turin, and Genoa. Switzerland tends to manufacture articles small in bulk but large in value and demanding much skill in their assembly, such as watches and clocks. The nation has no coal supplies near at hand but enjoys a considerable development of her hydroelectric power. Barcelona, Spain, and Marseille in southern France are important manufacturing cities of the western Mediterranean, with the former noted for its cotton textiles, with which it supplies Spain's needs.

In the *U.S.S.R.* great efforts have been made to industrialize the country and recover from

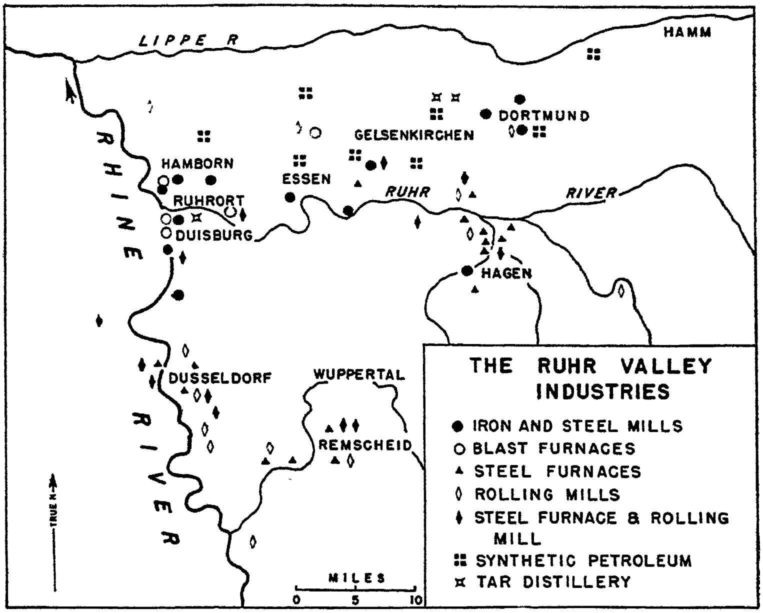

FIG. 238. Ruhr Valley industries. (*Data used by permission of Chauncy Harris.*)

the great destruction experienced during the war, in which its cities and industries were seriously damaged. Coal deposits in the Donetz Basin and near Moscow are of great help in supplying fuel for Russian factories. Water power has been developed on the Dnieper River. Before the war, Kharkov, Rostov, and Stalingrad were important centers of heavy industry. Moscow, like most large cities, has numerous manufactures, including textiles, publishing houses, clothing, and food processing. The southern Urals, with some coal and much iron ore, in company with other minerals, have important plants for steel and iron and munitions at Magnitogorsk, Sverdlovsk, and other centers. Farther east in Siberia, steel and chemical plants are located at Stalinsk and other cities in the Kuznetsk Basin.

Eastern and Southeastern Asia. *Japan* has only small and limited coal fields, and even less iron ore, but her minerals are readily accessible for manufacturing. Before the recent war, Japan led Asia in its development of heavy industry. This depended partly on hydroelectric power, in which Japan led Asia, and also on her imports of coal and iron from Manchuria and Korea, coal from Indo-China, and iron ore from the Philippines. Most of Japan's oil was imported. The country also had to buy almost all its supply of raw cotton abroad, and it needed rubber and many other essential materials in order to maintain a modern manufacturing economy. The industrial base was therefore unsound, although the nation was a large exporter of cotton, rayon, silk, cement, and many small manufactured articles. The future of manufacturing in Japan is not clear, but it probably lies along the lines of light industry rather than heavy goods. The shipbuilding and armament industries will not be likely to regain their former importance. The coastwise location of most of Japan's industries, and their concentration in relatively few cities, made them highly vulnerable during the war. Tokyo, Yokohama, Nagoya, Osaka, Kobe, and Kyoto were the leading industrial centers.

China has lagged in industrial development, and much destruction of her manufacturing establishments during the war will further retard her. China has large coal deposits and an abundant labor supply. Shanghai was the leading city in industry, with Hankow

CHAPTER 22: *Transportation and Communication*

The communication of ideas and information, the transportation of man and his possessions, and the development of routes and carriers for the exchange of goods between people all facilitate the economic and cultural progress of man. Modern rapid communication reaches most parts of the earth and supplies the information needed by governments, businessmen, and individuals in order to reach decisions of all kinds—political, economic, military, and the like. The ease of communication is a strong unifying factor within a nation, tends to provide bonds of common interest between different nations, and in general is of paramount importance to human society.

The Value of Communication and Transportation

Primitive peoples can communicate for short distances by means of smoke signals, by drums, by human runners, or by riding animals. Today we use the railroad, ocean ship, automobile, telegraph, telephone, cable, newspaper, and radio. Those qualities which tend to develop among peoples as the natural result of isolation tend to disappear when modern radio and highway reach them; in this country, for example, "Americans" differ so little it is hard to tell from what part of the nation an individual comes. This tendency toward uniformity has been one of the results of our excellent systems of communication, by which we have spread ideas, knowledge, and education among most of our citizens.

People who must live in areas lacking efficient transportation must practice subsistence farming and construct for themselves most of the articles they desire, or go without them. Only a few wealthy people can afford the high cost of transport of imported goods; and, because under these circumstances only a few items can be exported, the volume of trade remains small. Improvements in transportation and the reduction of costs make possible the exchange of commodities—an expensive and difficult procedure unless transportation conditions are favorable. The total result appears in gain for both the producer and the consumer, with consequent increase in the volume of world trade.

Man's conquest of space through modern communication, transportation, and the transmission of electrical energy ranks among his greatest achievements. Until these services were adequately and economically available, there was no escape from primitive existence in the past or advancement from low standards of living in the present. The whole economy of the world depends upon its pattern of transport, transmission, and communication facilities. The development of transportation and the trade that naturally follows are fundamental to the extension of knowledge, expansion of civilization, and spreading of culture and empires. Natural factors affect transportation routes on each continent and on the ocean. The location and growth of cities for trade and industry discussed in a later chapter depend to a great degree upon transportation.

Primitive Transportation and Development of Trade. Even among primitive people there is need for some transportation and trade. The Eskimo requires a dog sled to bring home his captured seal; the northern forest Indian uses the birchbark canoe to carry his catch of furs to market and bring back a steel trap or some other necessity that his environment does not provide. Caravan routes over

[1] Aspects of Inland Navigation of Waterways were discussed in Chap. 20.

desert wastes show the need for crossing the broad barrier separating two productive regions as well as for supplying the needs of the few inhabitants. The Norsemen fearlessly sailed the stormy North Atlantic and settled in Iceland and Greenland nearly a thousand years ago. Likewise the Polynesians, aptly called the "Vikings of the Pacific," early in the Christian era left southeastern Asia and explored the previously unknown Pacific; they discovered and populated all the island groups from Hawaii to New Zealand and eastward to the Marquesas Islands, Tuamotu Archipelago, and Easter Island. Thousands of years ago traders brought amber from the Baltic regions to the Mediterranean on the backs of men and animals through the same passes and routes later followed by the railroads. Seashells were brought far inland by the North American Indians, who also exchanged turquoise, copper, pipestone, jadeite, and obsidian over distances up to 1,000 miles or more.

The Growth of Trade. Trade tends to develop between regions having more products on hand than they can use conveniently; the growth of trade is particularly noticeable when these surplus commodities are of different type. Among the circumstances favoring the development of trade between groups of people are (1) differences in the stage of economic development, for example, a region in which manufactured goods are important and one in which there is surplus production of raw materials; (2) differences in climatic condition, such as those between the progressive and humid mid-latitudes and the relatively backward tropical lands, subpolar regions, deserts, and steppes; (3) differences in the type or quantity of natural resources—minerals, timber, and fish, for example.

Trade of the United States. A large part of the imports reaching the United States come from the tropics. Among these commodities are rubber, coffee, tea, cane sugar, jute, hemp, coconut and palm oil, bananas, cacao, and spices. From colder regions we buy paper pulp, fish, furs, and some animal fats, though their value is much less than that of products from the tropics. In minerals we import tin and several metals used in alloy steels. From Europe we import certain manufactured goods like watches, clothing, jewelry, and art objects, which differ from our own manufacturing specialties or are preferred by buyers to the home product.

Formerly Europe exchanged its manufactures for the raw material and foodstuffs of the United States and other countries that were not advanced industrially, but the increasing industrialization of our country and other nations has made it difficult for some European nations to sell enough manufactures and thus buy needed food and raw materials. In Latin America, China, and southeastern Asia the trade with the United States depends at times upon differences in climate, and in other cases—Argentina, for example—upon the degree of industrialization. For other nations, our trade may depend upon their possession of needed minerals, as in Chile with its nitrates and copper ore.

The Importance of Foreign Trade. The value of foreign trade of a country depends largely upon the self-sufficiency of that nation. Large countries usually can supply more of their own needs than small countries. Some small nations, like Switzerland, enjoy more foreign trade per person than a country the size of France, where the diversity of resources is great. In total value, Europe's foreign trade exceeds that of all the rest of the world, but in part this is the result of the small size of the nations on that continent and the numerous international boundary lines. What would normally be regarded as domestic trade in larger countries therefore becomes foreign trade in Europe. The domestic trade of the United States is about eight times our foreign trade, a proportion that indicates the self-sufficiency of our nation. Our self-reliance comes, of course, from the large size of the country and the great diversity of raw materials and labor available within its boundaries, as well as from our high living

standards. The total trade of the world approximates sixty billion dollars annually, of which the United States contributes about one-tenth of the amount.

The amount of trade is greatly affected by the economic level attained by different peoples. Asia contains over one-half the population of the earth; but, because its millions of people live at a relatively low economic level, their purchasing power per capita is lower than that for other parts of the world. In contrast, the volume of trade per inhabitant of western European nations is large because of the high state of industrialization and the standards of living attained there, resulting in large imports of foodstuffs, raw materials, and fuels, as well as the export of valuable manufactured articles.

Factors Correcting Unfavorable Balance of Trade. A feature of the foreign trade of most European countries is that the value of their imports exceeds that of their exports. Sometimes this represents purchases made from the proceeds of international or private loans and other forms of credit, but there are also certain "invisible" factors operating to correct the unfavorable balance of trade. The more important of these are (1) interest on foreign investments, (2) profits from ocean shipping, (3) insurance, (4) royalties and commissions, (5) money spent by tourists, and (6) money sent back to the homeland by emigrants. In nations like England income from these and other sources leads in most years to the accumulation of capital as well as payment for excess of imports over exports.

Transportation Methods and Transportation Routes

Many methods of transportation have been utilized in the advance of economic development. Man, pack animals, canoes and rowboats, sleds, carts, wagons, sailing vessels, steamships, railroads, motorboats, automobiles and trucks, and aircraft have been used successively for transport; curiously enough all are still used in some parts of the world. Modern means of transportation have enormously speeded up the exchange of commodities and have broadly extended the field of trade. The power used by the individual and by those machines which he can use has multiplied many times the work that can be accomplished in a given period of time.

The transportation routes of the world in the past have been either on the earth's surface or by use of the oceans and other waterways across both land and sea; transportation, in other words, was "land-bound" or "water-bound" or both. Now airways follow indifferently routes over land or water bodies; and, except for the weather conditions and the highest mountain ranges, they are largely independent of the facts of terrestrial geography.

Water Routes. The water routes are divided into ocean routes and inland waterways. The ocean connects all countries having seacoasts and forms a costless highway open to everyone. Some improvements are needed at seaports, such as wharves, fuel docks, warehouses, breakwaters, dredging, lighthouses, and other facilities; but their expense is small compared with that of building a railroad equal in length to an ocean route. Most rivers require some expense to make them useful for transportation; the necessary depth of channel must be maintained, but the total cost is low compared with the cost of a paved highway of the same length as the river. The Great Lakes, a superb inland water route, are like enclosed seas in their numerous advantages for shipping. Operating cost of ships per ton-mile for freight shipments is much lower than for any type of land transport—a prime advantage to those who are in a position where they can use water transportation. For bulky commodities, rivers and canals are excellent means of transport, but the service is slow, and railroads or motor trucks are therefore preferred for shipments requiring speedy delivery.

Ocean Trade Routes. Various factors determine the locations of ocean routes, which are

not fixed like those of the railroads; steamship routes may be changed from time to time with little difficulty if there is need for a different route. The general conditions that govern the routing of ocean trade include (1) the distance that must be traversed in order to reach the desired destination; (2) ocean currents that may help or hinder the speed of the vessel; (3) the prevalence of fog, ice, or storm conditions; (4) the amount of freight available for cargo; (5) the location of fueling and supply stations on the route, and (6) in the case of sailing vessels, the prevailing winds that must be taken into account. In days of sail, ships might follow roundabout routes in order to take advantage of the reliable trade winds and prevailing westerlies, which could reduce the time of travel even though the total distance to the destination was greater. Now, with steam and motorship, the most direct practical route is followed, though ocean currents and the prevalence of floating ice may cause some divergence from the shortest route.

The *North Atlantic* is the most used route for ocean traffic; it connects the middle-eastern North American seaboard with western Europe (Fig. 239). These regions are populous and are highly productive of freight; some of the world's greatest seaports are terminals of this route. The North Atlantic sea lane branches on its eastern end into the Mediterranean, and it also has a branch leading to the Baltic Sea. A few ships go to the far north past North Cape, heading for the arctic ports of Europe. The Mediterranean–Indian Ocean route to Asia is an important traffic lane and has been called in England the "highway of empire," since it is one of the principal links connecting the colonial possessions. It leads from western Europe through the Mediterranean Sea, the Suez Canal, the Red Sea, and the Indian Ocean to southeastern Asia and Australia. The building of the Suez Canal shortened the journey from England to India by 4,000 miles. During the Second World War, strong efforts were made by Italy and Germany to cut this line, and for a time shipping bound for the Far East was forced to detour around Africa by way of the Cape of Good Hope.

The South African route from Europe serves ports of western and southern Africa and continues on to Australia and New Zealand. Formerly this was also the main route to Asia, and it is still followed by sailing ships and freighters if their owners wish to avoid payment of canal tolls at Suez.

The route from Europe to *South America* is important for shipments of freight; it serves ports on the east coast of South America, although a few ships continue to use the Strait of Magellan to reach the west coast or to continue on their way to Australia. Sailing vessels find it easier to round Cape Horn than to use the strait, where there is little sea room; furthermore, they can maneuver better in the open sea because they must sail into the "Roaring Forties" in these latitudes.

The *Panama Canal* route connects the eastern and the Gulf Coast ports of the United States with the west coast of both North and South America. Ships also use this route between Europe and western American ports. Some ships moving from Europe and from the eastern United States traverse the canal route on their way to the Orient and Australia. Needless to say, the Panama Canal is of highest strategic importance to the United States, but its use to shorten the commercial route between our eastern and western coasts should be appreciated also. The construction of both the Suez and the Panama canals was responsible for shortening and realigning the older ocean trade routes.

The *North Pacific* route connects western North America with eastern Asia. The shortest way is to follow the great-circle route, which lies toward the north near the Aleutian Islands. Passenger liners to the Orient normally take a route that diverges from a direct course between terminals to break their voyage at Honolulu, Hawaii, a natural midocean crossroads. Another route in the Pacific extends from the western coast of the United States and Canada to Australia and New Zea-

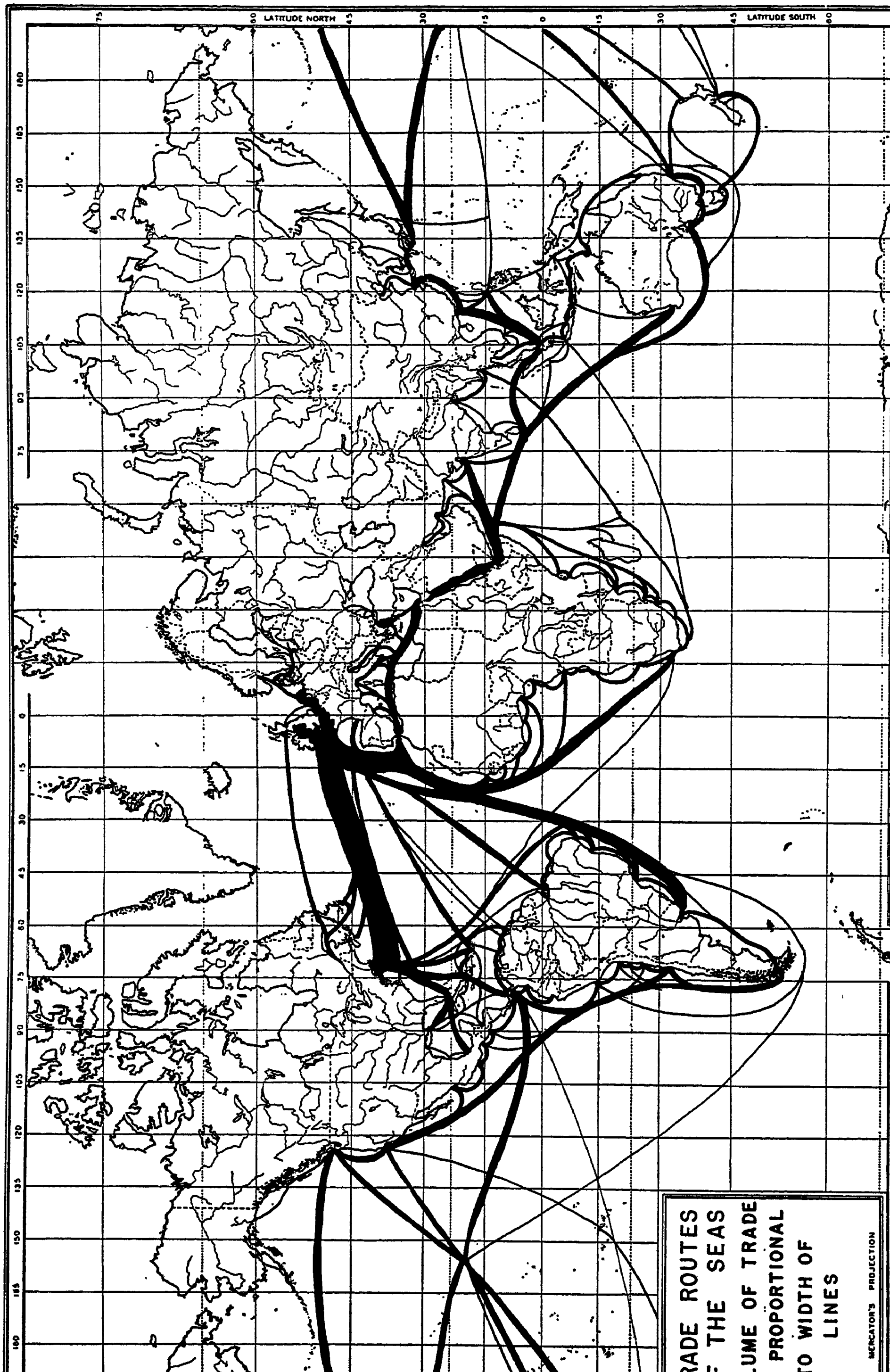

Fig. 239. Trade routes of the seas. *(Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.)*

land. Ships following this route also may go by way of Honolulu and may stop at Suva in Fiji and at Pago Pago in Samoa. A few ships use a route from eastern Asia bound either southward to Australia or eastward to South America, but trade in this part of the world is small and passengers are few. In general the Pacific Ocean routes are much less important for ocean shipping than the Atlantic routes, partly because some of the shores of the Pacific are thinly populated. Further, Asiatic peoples though numerous do not enjoy a high purchasing power, which would lead to increase of trade and shipping.

Ocean Shipping. Fueling, repair, and *supply stations* for ships are sometimes established at strategic locations on islands or on the mainland when coastal sites are placed approximately on the courses of ocean trade routes. Sometimes these installations serve a dual purpose as naval and air bases. Aden, Gibraltar, Malta, Port Said, Mauritius, the Falkland Islands, Azores Islands, Virgin Islands, and Punta Arenas (Magallanes) are important service points for ocean shipping, and some of these also are fortified.

Ocean Carriers. Ships are economical carriers for several reasons. The ocean right of way is free to ships of all nations. Ocean shipments cost less per ton of freight than movements of goods by railroad cars; labor and other operating costs are less than on land routes. When goods can be shipped by water, the ocean routes are preferred because of their low rates, and large quantities of freight are carried by coastwise vessels. Legally in the United States, coastwise shipping includes traffic between all ports under our flag and traffic to and from Hawaii and Puerto Rico and the mainland, or to Alaska; all this is called *coastwise.* By law only United States ships can engage in this trade. Many other countries have similar legislation.

Three principal types of ocean carriers are in use, the liner, the tramp steamer, and specialty ships like tankers, ore carriers, or refrigerator vessels. Naval vessels constitute a specialty class in themselves.

The *liners* follow recognized routes, move on regular schedules between designated ports, and frequently combine freight shipments with passenger traffic and mail shipments. Their freight usually consists of shipments of relatively valuable products that are of small bulk and are "clean" in handling. Liners as a rule would not take on a cargo made up of strong-smelling substances like copra, dirty materials like coal, or bulk shipments like wheat. Some luxury liners carry little freight and specialize on speed and passenger service; this type of vessel generally is found on the Europe–North America run. On the whole, however, it is the small, dirty, and unspectacular freighter that handles the major part of the world's freight shipments. Some liners, on the other hand, are essentially freighters sailing on schedule and carrying passengers as a side issue.

Tramp steamers follow any ocean route and move at any speed, since they are not bound by shipping schedules. They arrange to go from port to port, picking up cargo and discharging goods according to the freight that may be available at the time. They carry the bulk of the world's ocean freight. Some tramp vessels rarely visit their home ports; some may return to their home port on the average about every 3 to 5 years.

Among the *specialty* boats of importance, the tanker has a strategic position. The tankers specialize on the transportation of petroleum (Fig. 240); and its products but are sometimes used to carry vegetable oils; this can be done successfully if the holds are steam-cleaned properly. The *ore carrier* is especially important in ocean shipping and particularly so on the Great Lakes. Ore carriers operate on regular routes, transporting iron ore from Chile, northern Spain, northern Sweden, or Algeria to consuming markets. They can also transport coal, phosphate rock, and other heavy and bulky commodities. Refrigerator ships are used principally to carry meat and bananas. They often carry passengers as well and may run on regular schedules as liners. Other specialty boats include cattle

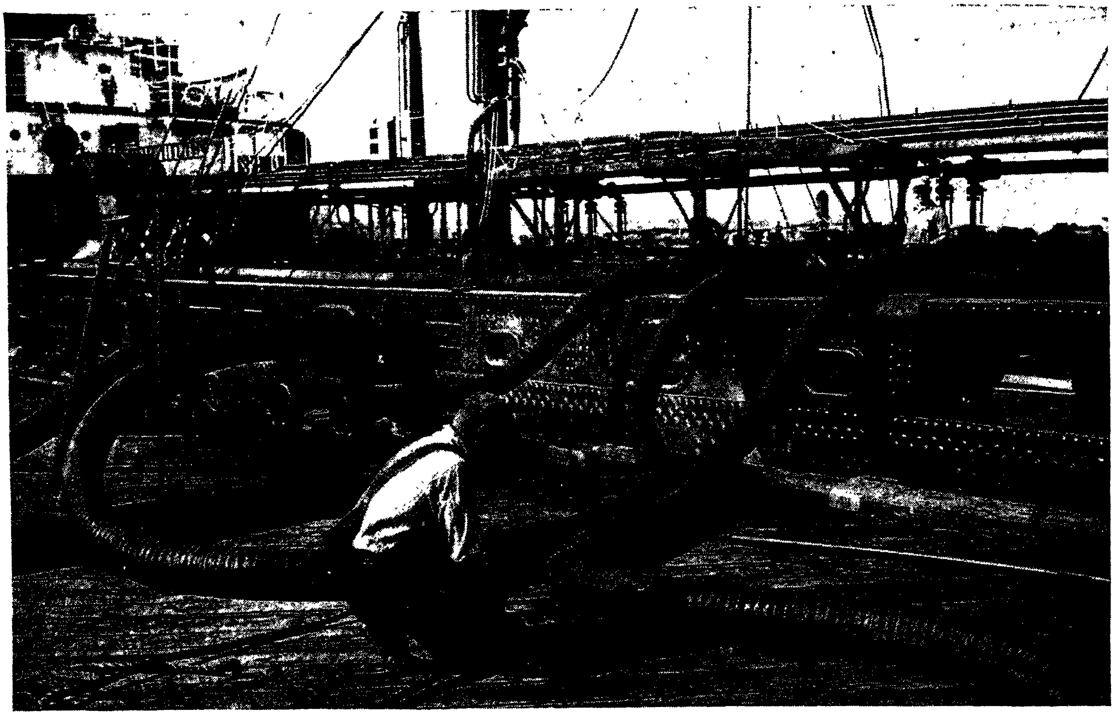

FIG. 240. Modern method of loading crude petroleum from storage tanks on shore into the hold of an oil tanker for shipment by sea. (*Photograph courtesy of the Los Angeles County Chamber of Commerce.*)

boats, cable vessels, whaling ships, and ice-breakers.

Merchant Marines. The war caused great destruction of ocean shipping and enormous dislocation of transocean freight and passenger services. In 1939 the world's merchant fleet totaled 58 million gross tons, of which the United States owned 8 million tons. In 1946 the world's gross tonnage was 71 million, of which this country owned one-half. The British Empire, despite the wartime losses, was second with 18 million. The proportion of the world's ships owned by the United States will certainly decline as the postwar world returns to normal trade and traffic, but how much of a change will occur remains to be determined.

Before the war, the leading nations of the world in ocean shipping were the British Empire, United States, Japan, Norway, Germany, Italy, France, the Netherlands, Greece, Sweden, the U.S.S.R., and Denmark; each nation operated over 1 million gross tons of shipping. The total number of vessels larger than 1,000 tons burden owned in 1946 was 12,445.

Land Routes. Land routes seek the shortest and easiest path connecting two points, although political considerations, subdivisions of land, certain relief features, and unusual sources of freight may lead to divergence from the most direct course. Mountains or hills, swamps, lakes, wide rivers, and inlets of the sea are physical barriers that usually call for some deflection of land routes. Deserts and other unpeopled regions are avoided when possible, since little or no freight would be available in those areas. Generally there is a close correlation between dense networks of railways or highways and the density of populations.

The first burden bearer was man himself, and he is still used for this purpose in tropical Africa, New Guinea, and a few other remote places. Pack animals, the dog, horse, camel, yak, llama, and others, were domesticated at a relatively early stage in man's cul-

ture history; they are still in use in some mountains, deserts, and other little-developed regions. Canoes, rafts, and other boats were built for use on streams. The invention of the wheel and the comparative ease with which goods can be transported by wheeled vehicles was a significant advance in transportation (Fig. 241); it released man from so much dependence on his domesticated animals and on his own efforts. The use of the wind for propelling boats on both the ocean and inland waters also helped him greatly, and the invention of the internal-combustion engine and its application to transport has been of tremendous importance to trade and travel in our time.

Explorers and early settlers in a region usually plan foot and horse trails, which are followed later by the construction of roads to accommodate wheeled vehicles. If the commercial development of the region proceeds and the population increases accordingly, the highways are improved for use by automotive equipment, or railroads are built. The degree of improvement and the surfacing of the roads will depend upon such factors as the amount of traffic, available funds, the physical features of the landscape, and the stage of human progress in the area.

Highways. Until man began to use roads, exchange of commodities and ideas was very slow. Highways are important factors in the advance of civilization and in the spread of culture throughout the world.

Most roads were built at first to serve local needs for transportation, although some roads today may be hundreds or even thousands of miles in length. Early roads were largely of the farm-to-market type, connecting seaports with their hinterlands, or built to serve as portages connecting navigable waterways. Longer roads were built between the great cities, like the Tokyo-to-Kyoto highway in old Japan or the early highways connecting ancient capital cities of medieval Europe. The old "silk road" from China to the Mediterranean was a caravan route on which only luxury goods could afford the costs of transport. Some roads were developed to aid the growth of pioneer settlements, including the Cumberland Road across the Appalachian barrier to the Ohio River country, and the Wilderness Road down the Great Valley of Virginia to Kentucky and Tennessee. These and other routes were followed by thousands of settlers during the early days of expanding settlement in the United States.

Other famous American highway routes include the Santa Fe Trail, the Overland Trail

FIG. 241. Vehicles, drawn by animals, still move people and goods long distances in remote parts of the world. This modern version of the covered wagon may be seen in parts of New Mexico and Arizona today.

to California, and the Oregon Trail; these were used by settlers and traders long before transcontinental railroads were built (Fig. 242). The famous Natchez Trace was an overland route by which traders who had taken their goods down the Mississippi on flatboats could return to Ohio by a route northward and eastward from Natchez through Nashville to Cincinnati and Pittsburgh. Zane's Trace connected important early settlements in southeastern Ohio. The Chisholm Trail, extending from the Gulf coast of Texas through Oklahoma, Kansas, and Nebraska, was an important cattle trail during the middle years of the nineteenth century. On the west coast, El Camino Real (the king's highway) was a trail connecting the 21 California missions.

The pattern of roads as it appears on maps is often related to the physical features of the terrain. In the plains regions roads normally follow straight lines, especially in those parts of the United States and Canada where the land was subdivided on a checkerboard system based on meridians and parallels. In steep hilly regions the roads wind to adapt themselves to the hills. In swampy land the highways seek the higher ground and the divides that separate water bodies. Desert roads may connect watering places as well as settlement and ranches. Mountain highways often converge at either end of a pass, and as a rule they tend to follow the valleys if it is possible to do so.

Some highways are built primarily for military or other strategic purposes or to reach frontier boundaries or unite the outlying parts of a nation. Such a road extended from Leningrad and Moscow across Siberia to the Pacific and was used by sleds in winter as well as by wheeled vehicles in summer. During the Second World War the Alaska Highway was built from Dawson Creek, British Columbia, to Alaska for strategic reasons. Another strategic highway was the "Burma Road" from Burma into China; this highway has deteriorated rapidly since the close of the war.

The paving of roads helps speed up travel, lowers the costs of carriage, and decreases the danger of interference by bad weather conditions. The Romans built paved military roads that bound their empire together, but these roads served the additional purpose of promoting exchange of merchandise between the outlying parts of the realm and the capital city. The Indians in the mountains of Peru built paved roads upon which foot travelers and llama caravans were able to reach distant parts of the Inca empire; these roads, like those of Rome, contributed greatly to unite the political divisions of the nation.

Highway Transport in the United States. The development of highways is generally related to the degree of industrialization and the density of population of a nation. The United States enjoys more paved highways than any other country (Fig. 243), for we have more than 750,000 miles of them. The roads in the United States total over 3 million miles in length—about 1 mile of road for each square mile of area—but three-fourths of this mileage consists of unpaved roads that are used principally for local traffic. Trunk-line highways, all paved and controlled by the Federal government, total over 70,500 miles; highways controlled by the state governments total about 550,000 miles.

Highway Transport Abroad. Western Europe has a close and intricate network of roads, many of which are paved. The U.S.S.R. is second to the United States in its total road mileage. Japan has a dense network of roads, but most parts of Asia are not well served by highways, and extension of the paved roads is desirable. There are few roads in the tropical parts of Africa or South America; there, water transportation by means of rivers may take the place of transportation by land routes (Fig. 244). In a few places in the tropics, however, short rail lines and highways are vital connecting links around obstructions to river transportation; this is true at many points near the coast of Africa where the rivers from the interior are interrupted by falls or rapids as they plunge over the edge of the central African plateau before reaching the sea. Highways are being extended in

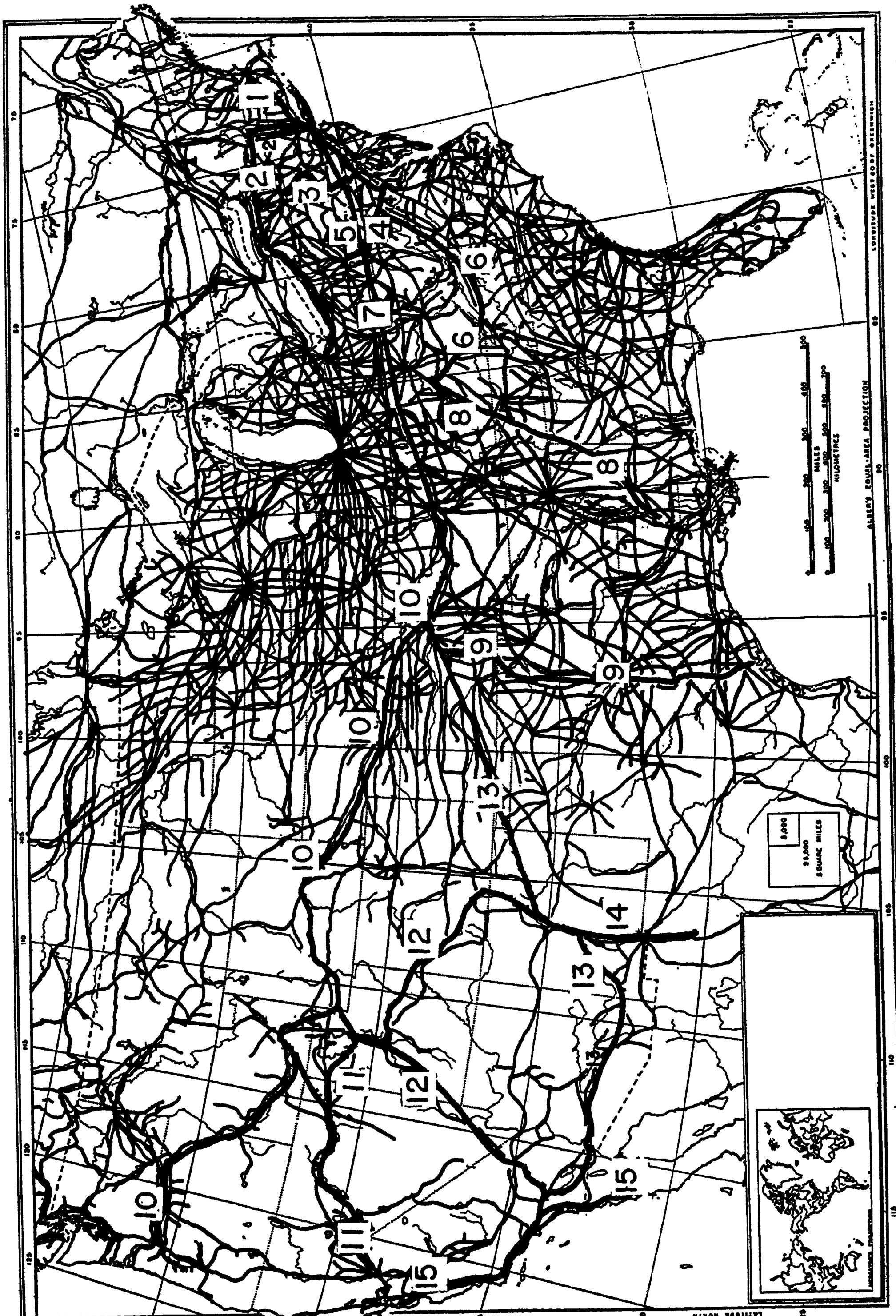

FIG. 242. Railway network of the United States, with early routes of land transportation. 1, Boston Post Road; 2, Mohawk-Hudson route; 3, Susquehanna Corridor; 4, Braddock Road; 5, Forbes Road; 6, Wilderness Road; 7, Cumberland Road–National Road; 8, Natchez Trace; 9, Chisholm Trail; 10, Oregon Trail; 11, California Trail; 12, Spanish Trail; 13, Santa Fe Trail; 14, Jornada del Muerto. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

FIG. 243. Cahuenga Pass freeway leading from Los Angeles northward to the suburban sections of San Fernando Valley. Note highways for local traffic, for high-speed through traffic, and the double-track electric line. Typical vegetation cover of the Hollywood Hills and Santa Monica Mountains in the distance. (*Photograph courtesy of the Los Angeles County Chamber of Commerce.*)

Mexico and several South American countries, where they help attract tourists as well as serve the needs of local residents. The Pan-American highway, when it is completed, together with its connections, will permit automobile travel from the United States to all the Latin-American countries. The populated parts of Canada, Australia, and New Zealand are generally well supplied with roads.

Motor Transportation on Highways. The vast expansion in the use of automotive equipment since 1900 has stimulated the paving of roads and the invention of machines by which paving can be done more quickly and cheaply than by the hand methods once widely used. Motorcars, trucks, and busses represent a modern development of transportation, but their efficient use is not possible unless the principal routes of travel have been paved. There are nearly 35 million automotive vehicles licensed to operate in the United States. Our country owns 70 per cent of the world's automobiles, 60 per cent of the trucks, and about the same percentage of busses. More than 45 million motor vehicles are in use in the world, of which about 35 million are automobiles, 9 million are trucks, and about 500,000 are busses. In addition many tractors are used on the farms of the United States, the U.S.S.R., Canada, and on the mechanized farms of other countries.

Much traffic that was formerly handled by railways now is transported by motor vehicles. Motorcars, trucks, and busses are flexible in their movements and their routes compared with the movement of rail traffic, which is restricted to tracks. In addition, motor vehicles on highways can travel on steeper grades than railway trains can, and for short distances they about equal the speed of rail travel. Throughout the entire United States, Canada, western Europe, and wherever highways have been built for them, trucks and busses have become important common carriers. They are

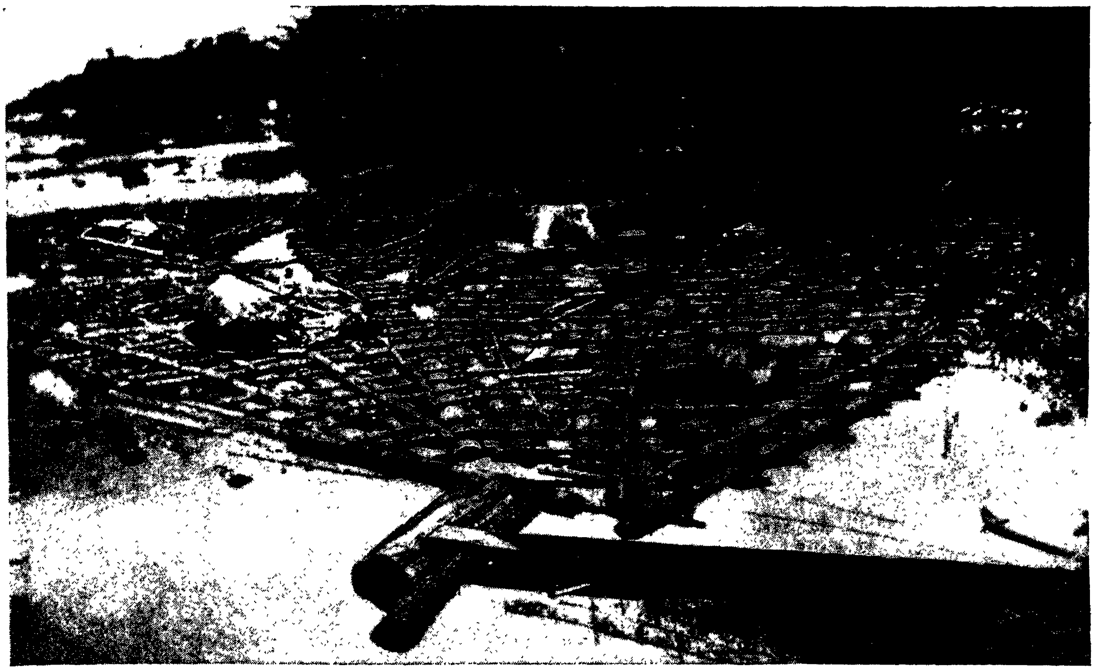

FIG. 244. Transportation of hardwood logs in the tropics is difficult and expensive. Here mahogany logs have been assembled and made into a raft for shipment downstream. Compare this view with similar operations in mid-latitudes as shown in Fig. 126. (*Photograph courtesy of the Mahogany Association, Inc.*)

especially well adapted to the quick transport of passengers, package freight, and perishable goods if the shipping distances are not too great. Trucks do not always have the advantage in transporting certain types of goods, particularly those which are of large bulk or those which can best be transported by air because of their perishable nature. Nevertheless the advantages of highway transportation are appreciated widely, and there is a tendency for motor transport to increase in volume almost everywhere. There are about 240,000 miles of bus lines operating in the United States, a mileage somewhat exceeding that of the total mileage of railroads in our country (226,000 miles).

Railway Transport. Railroad construction requires a great amount of capital to build a level roadbed, bridges, and tunnels and to install railway stations, lay track, and produce many other types of construction. It also calls for a high degree of skill in engineering. The rail lines tend to be built in the most highly industrialized and fertile farming regions, because in those parts of the earth there will be sufficient need for their services to provide them with funds for construction and for operation. Occasionally railroads have been built for military or other strategic purposes, in order to reach a productive region or coastal outlets beyond desert and mountain barriers or to open scenic areas for pleasure resorts. The main trunk railroads have terminals at the chief seaports or leading inland cities. From these main railroads, branches lead into the tributary territory as dictated by trade conditions and the productive capacity of the region. Government controls over rates, tariffs, and labor costs also affect railroad construction and operation.

The United States, Canada, most European nations, and some regions on other continents are well supplied with both railroads and highways (Fig. 245). Complete systems of transportation permit wide distribution of goods, rapid exchange of ideas, and conse-

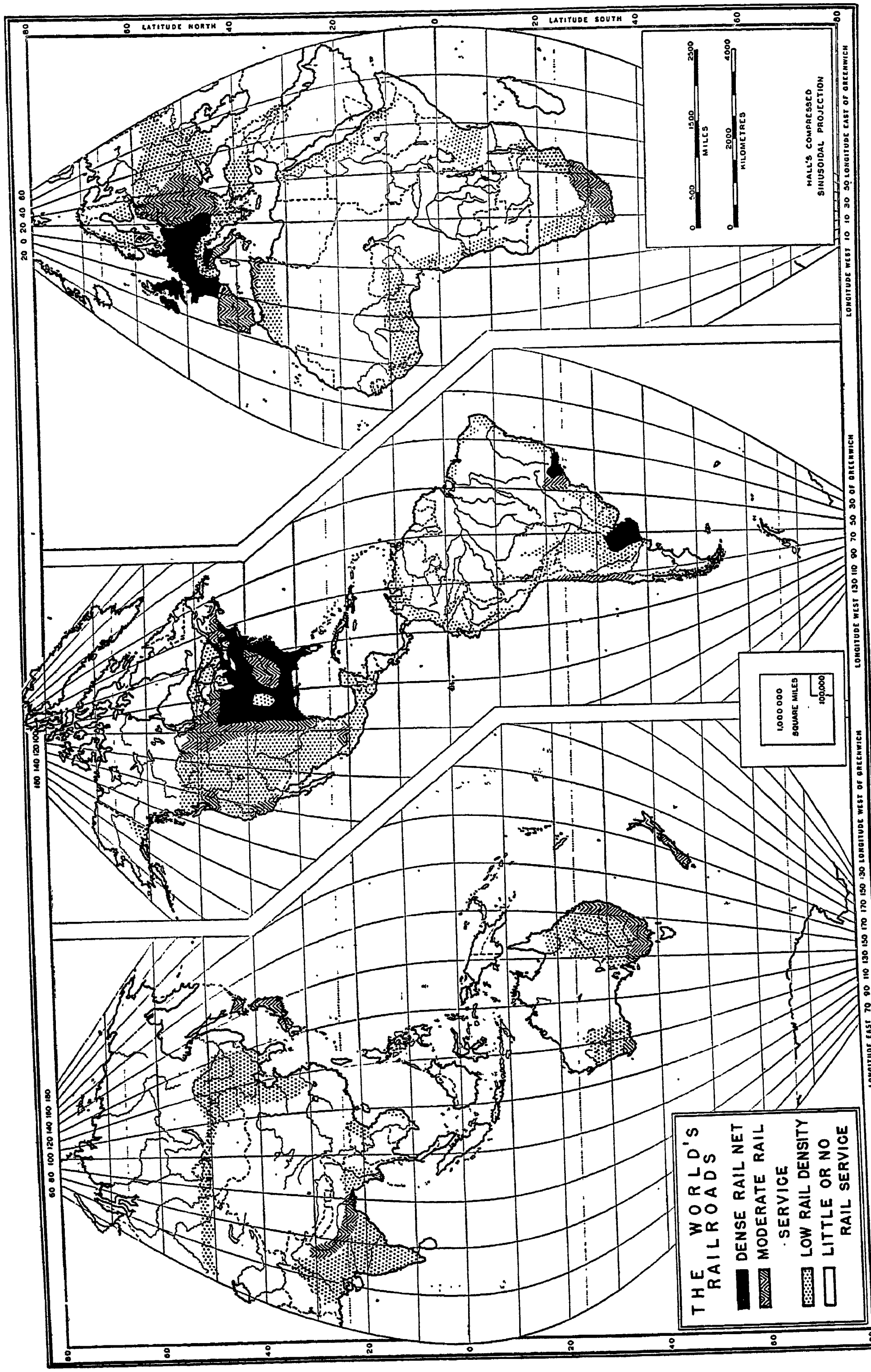

FIG. 245. The world's railroads. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

quent high standards of living—at least during periods of peace and noninterference with trade by governments. So important are railroads for trade that the railroad transportation will be described for the different continents.

The first railroad began operations in 1825; and, from this small beginning in England, rail lines have spread over many parts of the earth in little more than a century of time. The railroad is particularly important in those sections of the world which engage widely in manufacturing and in world trade, as in Europe, the United States, Canada, and Japan. The railroads transport heavy loads at rapid speeds, and the support of the large modern city, the marketing of both staple and perishable farm produce, and the rapid exploitation of many of our forest and mineral resources are largely possible because of the railroads.

The rail mileage of the world is nearly 750,000 miles, of which about one-third is in the United States. The U.S.S.R. is second to the United States, with Canada, India, Germany, Australia, France, Argentina, Brazil, and Great Britain following. Japan has about the same density of railroads per square mile as the United States, and several European countries exceed our density, including small but densely populated countries like Belgium, Denmark, and the Netherlands.

The distribution of railroads, as is illustrated by the railroad map of the different continents (Fig. 245), shows several densities. The eastern half of the United States, the Ontario peninsula in Canada, and most of western Europe have such a close network of railroads that only small areas are located more than 10 miles from a rail service. Russia, India, Japan, southeastern Australia, South Africa, and part of Argentina and Brazil have less rail service. In much of Africa, South America, Australia, and Asia the railroads are short feeders extending into the interior from the principal seaports.

United States railroads lead all countries of the world in length of mileage; they have helped greatly in the rapid development of our country and were even responsible in some states for the settlement of farming land and for the establishment of towns and cities. Some of the earliest railroads were built to connect existing cities, or ports and rivers, but soon the rail lines were extended beyond the frontiers of settlement and in defiance of the river systems. The importance of railroads in the development of the United States is indicated by the public's familiarity with railroad names. The names of railroads like the New York Central lines, the Pennsylvania Railroad, the Atchison, Topeka and Santa Fe, Union Pacific, and Northern Pacific are as well known to most Americans as are the great rivers of the nation.

From such Atlantic seaports as New York, Philadelphia, and Baltimore, the railroads of the northeastern United States pushed inland to reach the fertile farms and industrial centers of the Mississippi Valley and the Great Lakes regions. Among these railroads are the New York Central, the Pennsylvania, the Erie, Chesapeake and Ohio, and the Baltimore and Ohio, the last being the first railroad to be started on this continent. These lines cross the Appalachian barrier by various routes, usually following the rivers and using the water gaps. The lowest "water-level" grade is that of the Mohawk-Genesee valley route, which is utilized by the New York Central. The Southern Railroad, with other lines, serves the Atlantic coastal plain southward to the Gulf states.

In the interior, Chicago is the preeminent focal center for railroads; but St. Louis, Indianapolis, Cleveland, Detroit, St. Paul, and Kansas City are among other urban centers toward which our rail lines tend to converge. From the Middle West, railroads extend south to the Gulf ports, westward to the Pacific, and north into Canada. Among the railroads from Chicago to the South are the Illinois Central, whose route tends to parallel the Mississippi River, and the Louisville and Nashville.

The so-called "transcontinental" railroads do not cross the continent but begin at Chi-

cago, St. Louis, or New Orleans. Chicago is the principal starting point for these lines. The railroads using the northern route are the Chicago, Milwaukee, St. Paul and Pacific; and, in combination with the "Burlington" Railroad, the Northern Pacific and the Great Northern lines. The Union Pacific occupies the strategic central route. Its main line extends from Omaha to Ogden, with connections to Chicago and other Middle Western points. From the oasis of Utah, lines run southwest to Los Angeles, west to San Francisco, and northwest to Portland, Seattle, and Spokane, with a connection north to Butte and Yellowstone Park. On the southern route, the Santa Fe operates from Chicago to Los Angeles and San Francisco, and trains run on other lines from Chicago to El Paso and thence by way of the Southern Pacific to California.

From St. Louis a combination of the Missouri Pacific to Pueblo, Colorado; the Denver and Rio Grande to Salt Lake City; and the Western Pacific to San Francisco offers a route through the scenic Colorado Rockies—a difficult route avoided by other rail lines.

The Southern Pacific offers through service from New Orleans to California on its Sunset Route, and from there the Shasta Route of the same line connects with rail facilities at Portland, Oregon.

Canada's railroads consist of the privately operated Canadian Pacific and the government-operated Canadian National Railways. Both lines have eastern terminals at Montreal or Quebec, and connections with Halifax, Nova Scotia. Their Pacific terminals are located at Vancouver, British Columbia. The Canadian National Railways also reaches the Pacific at Prince Rupert, British Columbia. The Canadian lines are truly transcontinental in that they operate through trains from Atlantic to Pacific seaports.

The principal interior railroad center of Canada is at Winnipeg, near the southern end of Lake Winnipeg. The railroads from the western Canadian prairies converge at Winnipeg, just as the railroads crossing the Great Plains meet at Chicago. From the plains west of Winnipeg, a rail line has been built to Port Churchill on Hudson Bay; this line was built in order to help in the export of wheat to England, but it is handicapped because its terminal on Hudson Bay is frozen a large part of the year. Numerous railroads connect Canadian cities with railroads in the United States, and one loop of the New York Central operates through Canada between Buffalo and Detroit. Most Canadian railroads are located in Ontario, the prairie provinces, and just north of the United States–Canada boundary.

Mexico is moderately well supplied with railroads, considering the somewhat difficult climatic conditions and terrain of that land. Mexico City is the great focus of rail routes in the interior. Mexican railroads connect at several points with lines in the United States.

The railroads in *Central America* are short and of only local significance; some of them are little more than private lines built by corporations to serve the needs of their plantations.

Europe's railroad map indicates that the railroads of that continent tend to converge like the spokes of a wheel in the direction of the capital cities, with local convergence in the direction of major seaports and certain industrial centers. London, Paris, Berlin, Vienna, Warsaw, and Moscow represent the principal concentrations of railways; and Birmingham, Essen, Cologne, Leipzig, Dresden, Munich, Hamburg, Frankfurt, Antwerp, Rome, Kiev, Kharkov, and Leningrad represent smaller foci of railroads. Most of the large cities of Europe were founded before railroads were invented, and the lines were largely built to connect existing cities. This accounts for the prevalence of railroad centers from which the lines radiate in all directions. Some countries too have built strategic railroads to their borders from interior bases; these roads were constructed for military use rather than for the promotion of trade with neighboring nations. The longest railroad in the world is the Trans-Siberian line, which starts at Lenin-

grad and Moscow and continues to the Pacific at Vladivostok. To some extent this is a strategic rail line that serves to link the far eastern portions of the Soviet Union.

Numerous international boundaries, with their customs regulations and restrictions, are a serious handicap to the development of long-distance train service in Europe. Before the war, a famous rail route connected Paris and Moscow by way of Berlin. Another ran from Paris by way of Milan to Brindisi on the west coast of the Adriatic Sea. This line enjoyed fast connections with London and other capitals and carried mail for the Far East to steamers at Brindisi. Airplanes now carry much of the mail all the way to India and southeastern Asia. Another prewar route, followed by the famous "Orient Express" train was that from Istanbul to Vienna and Berlin, with connections to Paris, London, and Brussels. Ferries connect England with the continental rail lines and the Scandinavian peninsula with Germany and Denmark.

In contrast to the close network of railroads in most of western Europe is the more open net of railroads in Russia, Spain, and the Balkans—nations that are less developed from the industrial standpoint than the others of western Europe. In Russia waterways are used considerably for transport. Only a few rail lines reach the arctic ports of Russia, Finland, Sweden, and Norway.

Asia, with its great size and population, is inadequately supplied with railroads. Japan, which has a close network of lines, and India are among those parts which are moderately well served. China has some railroads but needs much more mileage than it now has before the remote interior parts of that nation can be developed for trade. The railroads of southeastern Asia and Java are of only local importance. The Trans-Siberian line is the only railroad crossing the continent; and, with its connections branching southward into Turkestan, it serves an enormous territory within the U.S.S.R. There are only a few railroads in Turkey and other parts of the Near East, and only one line in Iran. The high mountains and plateaus of central Asia are not readily penetrated by railroads, nor are there people or goods to justify the cost of their construction.

South American railroads are located principally in Argentina, Uruguay, southeastern Brazil, and Chile. Elsewhere the lines run inland from seaports and do not form a connected network. There are few railroads in the tropical parts of the continent. It is possible to cross the continent of South America along three possible routes, two of which pass through Bolivia, by using connecting railroads from Chile and Peruvian seaports to Buenos Aires. Much of the freight traffic of South America is carried by coastal steamships; mail and passengers move by air.

In *Africa* the continent is not well supplied with railroads except in British South Africa and in that part of North Africa controlled by France, where an open network of lines exists. Most of the railroads run from coastal ports into the interior, usually without connections with other lines. It is possible to cross Africa by rail by using several different railroads between the Portuguese colony of Angola on the Atlantic and ports in southeast Africa on the Indian Ocean, but travel by this route is slow and unsatisfactory and involves many practical difficulties. One famous African rail line, the Benguela railway, was built from that port on the west coast into the interior of the Belgian Congo in order to deliver supplies of valuable copper to coastal steamers. It would not have been necessary to build this line had the Congo River been more easily navigable.

Australia's railroads are mainly concentrated along the eastern and southern margins of that continent. One transcontinental railroad was built by the Commonwealth and extended inland some distance from the southern coast to connect the populated southeastern and southwestern parts of the continent. One rail line from the south penetrates to the community of Alice Springs near the desert center of the continent. Several lines have been built at right angles to the coast,

running short distances inland to gather freight for export from some of the ports. Much of Australia is too desert or too tropical in character to attract settlers or furnish valuable goods for export; it is therefore meagerly equipped with modern transportation facilities.

Air Transportation. The air is used for transportation mainly by peoples who are well advanced in industry and commerce, but airfields are being developed all over the world, with the result that increasing numbers of people and amounts of freight are being moved daily by means of the airplane. Aircraft are affected little by those natural barriers which deflect roads and rails from their direct routes (Fig. 246). At sea the air lanes may follow great-circle routes without interruption, but often the route will be planned to take advantage of stops on different island or shore bases. Some oceanic islands, formerly of little use to human beings, have great strategic value as bases in this day of increasing air travel; among hundreds of others, Canton and Wake islands in the Pacific and Fernando de Noronha in the Atlantic have assumed importance in recent years.

Air transportation began on a serious scale shortly after the First World War; its services were greatly enlarged and expanded after the Second World War. Today a network of air lines covers the United States and extends into Canada, Alaska, Mexico, Hawaii, and the Caribbean islands. Planes fly on frequent schedules to South America. Transoceanic planes cross the Atlantic to England and the continent of Europe, from which air connections extend into Asia and Africa. Over the Pacific Ocean, two flying lanes connect with Asia; one follows the North Pacific great-circle route, and the second uses several islands on its route by way of Hawaii, Midway, Wake, Guam, and Manila. Plane service is also available to reach Australia and New Zealand, with stops selected from Canton Island, Suva in Fiji, Noumea in New Caledonia, or Samoa, depending upon the route followed. Air lanes now encircle the world.

Air transport has the advantage of speed and is used for carrying passengers, mail, and freight items for which rates higher than those charged by land or sea can be paid. Airplanes are particularly adapted for rapid long-distance travel. The greatest concentration of air lanes today is in the United States and western Europe, but aircraft are increasingly used for passenger travel and freight deliveries to out-of-the-way locations where land routes are very poor and slow. This is particularly true in northern Canada in the taiga and tundra zones; in Alaska; in the interior of both humid and dry tropical Africa; in New Guinea, with its dense forest cover; and in the interior of South America, where railroads and highways are not available. In these and many other remote parts of the world the airplane has preceded railroads and helps bring comforts and necessities to the white residents. Weeks of travel can be saved in such regions by the use of planes.

Communications by Voice and Message. The communication devices—telegraph, telephone, cable, and radio—transmit ideas and messages with startling speed. All the world can receive the news at almost the same moment. The different means of communication are useful geographically in many ways, as in forecasting the weather; in obtaining information on supply, demand, and prices of commodities; in transmitting knowledge of international tensions; and in conducting business affairs. The cable has been supplemented by the radio for transocean messages, and the radio or wireless has proved a useful tool for business as well as for entertainment. Television may join the other means of communication in the near future as an important tool, but at present it is limited to only small local areas of reception.

The industrialized parts of the world are the principal users of modern methods of communication. About one-half of the world's telephones are in use in the United States, and one-third are in Europe. This country has one-third of the telegraph mileage, and much of the rest is in Europe. Nearly half of the

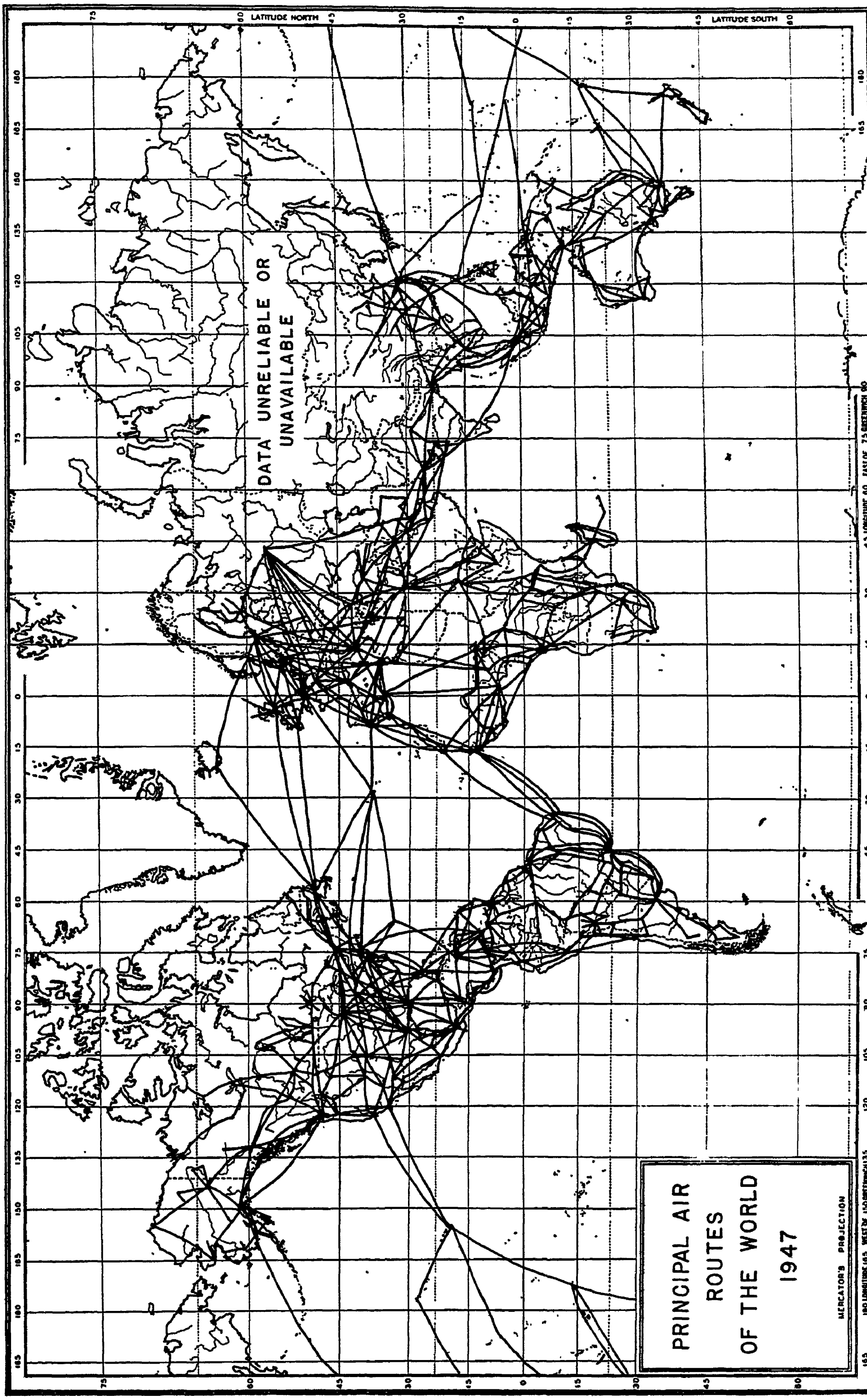

FIG. 246. Principal air routes of the world, 1947. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons. Data through courtesy of G. Etzel Pearcy and the Journal of Geography.*)

world's receiving radio sets are in the United States.

The first oceanic cable was successfully laid across the Atlantic in 1866, and several are now in operation in this part of the world. Cables cross the Pacific and have been laid from Europe to South America, Africa, and Australia. England's cable system extends around the world, and that country controls about half of the world's cables.

The radio is useful not only for sending messages but also for guiding airplanes through storm and fog, for communication with ships at sea, and for many military purposes. It has proved a valuable advertising medium and disseminator of news.

Problems

1. Why are the following regions poorly served by railroad lines: northwestern Maine; southern Florida; eastern Oregon; northwestern Colorado; southern Utah; northern Alberta; Albania; Norway?
2. Famous land routes of the world include the following. Select one, and investigate the type of traffic it carried, the type of vehicles used, the goods transported, and the cities that are related to it: Fertile Crescent, Oregon Trail, Santa Fe Trail, Cape-to-Cairo route, a trans-Saharan caravan route, the Silk Road.
3. Follow the same procedure for one of the following water routes: Suez route to India; India to China via the Strait of Malacca; New Orleans to Europe via Straits of Florida.
4. What traffic obstruction prevails on the route that connects each of the following cities? How has the problem been solved? Lake Erie and Lake Ontario; Spokane and Seattle; Denver and Salt Lake City; Calgary and Vancouver, British Columbia; Montreal and Quebec; Boston and Albany; Reno and Sacramento; San Francisco and Oakland.
5. What is the name of the principal transportation corridor that connects each two of the following cities: New York City and Albany; Birmingham and the Gulf of Mexico; Chicago and New Orleans; Montreal and Quebec; Pittsburgh and Cincinnati; Albany and Buffalo; Fargo and Winnipeg; Skagway and Dawson; Lake Superior and Lake Huron; Portland, Oregon, and Tacoma?
6. Summarize the advantages and disadvantages of the relative locations of the New York Central and the Pennsylvania lines; the Santa Fe and the Great Northern.
7. What is the principal transportation corridor connecting each two of the following cities: Vienna and Bucharest; Munich and Venice; Paris and Mainz; Edinburgh and Glasgow; Lyon and Paris; Prague and Vienna; Venice and Milan; Moscow and Kiev; Cologne and Mannheim?
8. What principal points do the following routes connect: Brenner Pass, the Iron Gate; Dardanelles; Uspallata Pass; Khyber Pass?
9. On a world map, draw the following movements of goods entering world trade, using arrows and, if necessary, different colors, between the place of origin and the principal consuming market: coffee, copra, tea, silk, tin, rubber, cacao, mahogany, jute.

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Note: The Bureau of Foreign and Domestic Commerce, Washington, D.C., publishes a wide number of pamphlets on this subject.

CHAPTER 23: *The Occupations and Distribution of the People of the World*

A paramount concern of the geographer and his subject is to determine where the people of the world live and why they live where they do. In such a study it soon becomes clear that the density of population is closely related to the ways by which man makes his living. Some occupations cannot be followed successfully without the use of large areas of land; others lead to close settlement and intensive use of small areas; and some economies develop into the complex organization of an industrial civilization, which has been accompanied by the extensive growth of cities.

The Occupations of Man

The people of this world have many different ways of earning a living, but most economies may be grouped according to the classification of human occupations which appears in Fig. 247. Some of these occupations may be pursued with comparative ease and involve no great amount of equipment or complex machinery, though they may demand a high degree of human skill and the application of intelligent thought.

Primitive Occupations. Primitive hunting and fishing call for skill in the manufacture of weapons and boats—harpoons, slings, arrows, traps, nets, and baskets (Fig. 248), as well as canoes, kayaks, paddles, and sails. Often the pursuit of these occupations leads to extensive migrations and travel. The products of the chase and the fishery are highly perishable, and primitive people must consume them soon after the catch has been taken. This leads to alternate periods of feast and famine, which the more capable men attempt to avoid by providing a more steady supply of food, either by the invention of methods of storage or by attempts to make the earth produce their needs by agriculture.

Many parts of the world are still occupied by people who live at low economic levels and provide most of their needs without recourse to processing of raw materials or exchange of commodities with their neighbors. The map (Fig. 247) indicates that parts of Borneo and New Guinea, the arctic shores, and most of Labrador and the northern interior part of Canada are populated by natives who rely on primitive hunting, fishing, and food collecting for their livelihood.

Human needs among primitive men also call for protection and shelter, and these may be obtained by taking refuge in trees or caverns. Shortly the search for shelter leads to the construction of houses, which can be built with relative ease from nature's supplies of grass (Fig. 67), timber, mud, or the skins of animals. The pursuit of these requirements, in addition to the need for fuel, led men to penetrate the dark forests. The tall grasslands with their wild life were searched for animal skins to provide shelter and clothing for human beings. Forest dwellers and wood users eventually came to rely on the trees for their principal needs and upon forestry as an occupation.

Those lands which are peopled by foresters and primitive farmers are found in many parts of northern Canada and Alaska, Scandinavia, north-central Asia, the Amazon and Congo basins, and southern Chile. Commercial lumbering is a principal occupation in Quebec, British Columbia, and the northwestern United States, as well as in Finland. Forested areas of the Southern Hemisphere are

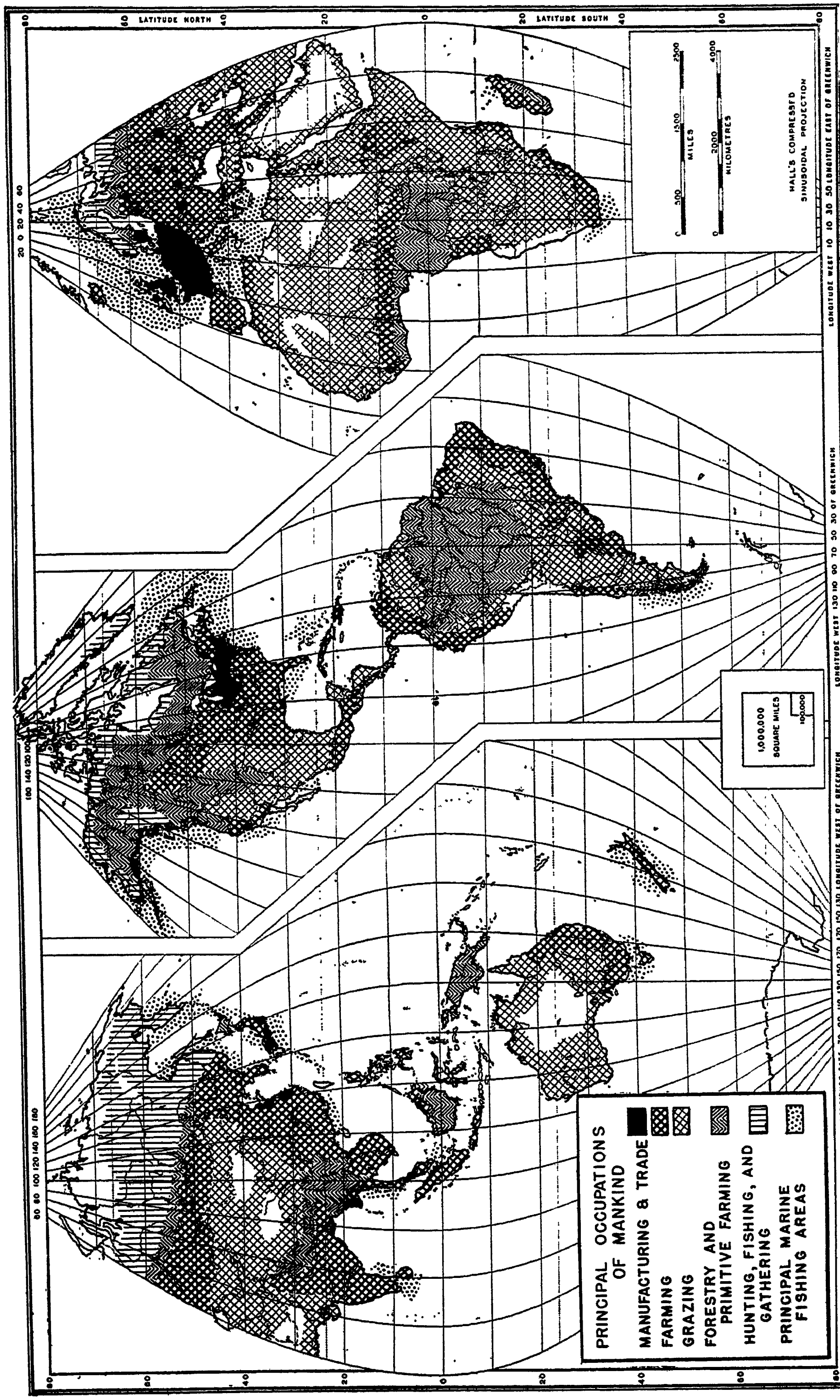

FIG. 247. Principal occupations of mankind. (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

FIG. 248. Primitive industry; a woman of the Quinault tribe making a basket from native materials at Taholah, Washington.

small compared with those of the Northern Hemisphere and are too distant from world markets for the commercial exploitation of large quantities of timber from those regions at present.

The Herdsmen. The change from the hunting of wild animals to the domestication of sheep, goats, cows, horses, and other adaptable creatures led to the establishment of grazing as an occupation. Extensive grazing at present is found both commercially and at the subsistence level in the mountainous parts of the United States and the Mexican plateau, the plains of the Orinoco and interior Brazil, the central Andes, Patagonia and western Argentina, throughout much of the Sahara and the Sudan, the South African veld, and interior Asia.

The Miners. Up to the point of development represented by the herdsmen, the relations of human economy to natural conditions were comparatively simple; but advances in civilization, especially the use of harder substances for tools and weapons, led to mining. Since the geographical location of such metals as iron, lead, tin, and copper is principally a result of geologic structure and deposition, and since the most favorable conditions are related to mountain-forming processes, men who depend upon the extraction of metals usually live in hilly or mountainous areas. Hence we commonly find mining and quarrying in the United States and Mexico; the central Andes; eastern Brazil; southeastern Africa; and in widely separated parts of Europe, Asia, and Australia where past geological conditions favored ore deposition. Not all minerals occur in mountains. Some iron and many of the nonmetallic minerals like coal, petroleum, clay, sulphur, and salt are among those frequently found in lowlands. All minerals are deposited where the geology is favorable to their formation.

The Fishermen. Increased seaworthiness of vessels made possible longer voyages and the corresponding development of both shore and deep-sea fisheries. Early man investigated the lakes for a supply of fresh fish; indeed his settlements were often located with reference to this food supply, near shallow parts of the Swiss lakes and along the shores of many shallow bays. Extensive prehistoric shell mounds line the shores of the lagoons and swamps around the edges of bays like those at San Francisco and Los Angeles. From primitive beginnings like these, the large fishing areas of the present day have developed, especially in the Northern Hemisphere, where the large population created a steady demand for the product. Typical fishing coasts include the

FIG. 249. Fishing for salmon near the mouth of the Columbia River, in the Pacific Northwest.

Pacific shores from California to Alaska (Fig. 249), Newfoundland and Labrador, Iceland, Scandinavia and the North Sea, the Mediterranean, and Japan and northeastern Asia. Except for whaling near Antarctica, the fishing grounds of the Southern Hemisphere are relatively unimportant and contribute little food fish to the world's supply.

Expansion of Agriculture and Industry. The human activities described above, as already noted, are relatively simple in operation and call for varying amounts of skill and exertion in their performance. Advances beyond this point, however, can be made through stimulation to greater need, and in particular the need arises when man's existence is threatened by the loss or failure of simply gathered food and fuel supplies. Then he is forced to make adequate provision against famine and hardship if he and his family are to survive; he begins to accumulate surplus commodities. With this development comes trade with his neighbors and the commercial development and processing of raw materials of all types. Agriculture becomes more intensive and specialized, as in the eastern and central United States; the plantations of the Netherlands Indies, Hawaii, Cuba, Central America, and southeastern Brazil; the La Plata region; most of Europe; and southeastern Asia. Fisheries are established on a commercial basis, and methods of food preservation are advanced.

Distribution of the World's People

The population of the earth is very unevenly distributed (Fig. 250). Both natural and human factors are involved in any explanation of the distribution of the people on the earth, but the great variations in population density can be explained to a large degree by geography. A comparison of the world maps of population density (Fig. 250) with those of rainfall (Fig. 47), temperature (Fig. 22), and natural vegetation (Fig. 55) will suggest these factors which help to determine the areas favorable to settlement and develop-

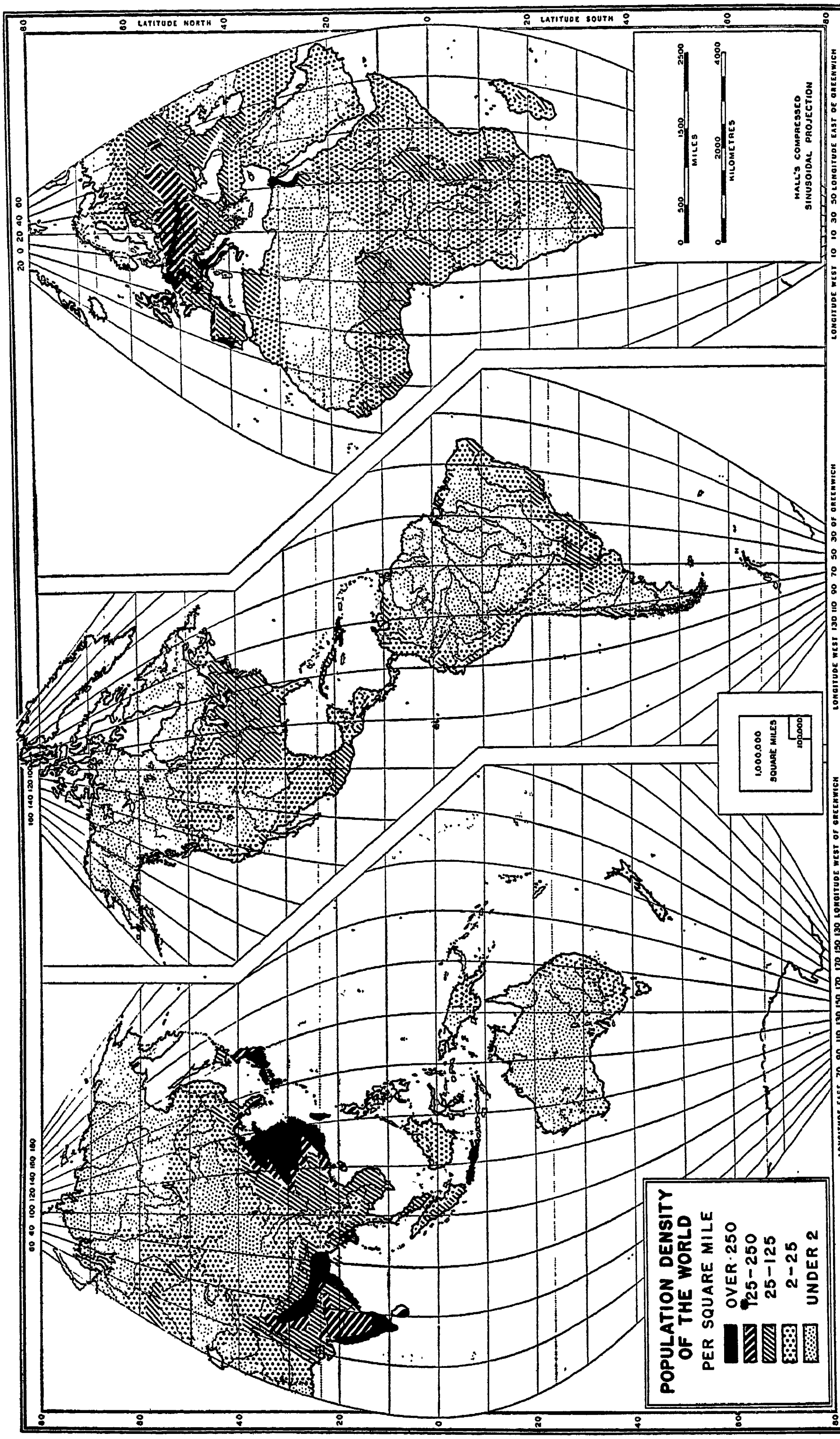

FIG. 250. Population density of the world (*Base map used by courtesy of R. B. Hall and the publishers, John Wiley & Sons.*)

ment, compared with other regions in which the natural conditions are unfavorable for human activities. Other factors affecting the distribution of population include the relief features of the earth, the proximity of the sea, water supplies, the occurrence of mineral resources, soil conditions, and location with regard to trade routes and world markets. In addition to the combined effect of various natural factors, certain human factors such as religion, habits, standards of living, and the general cultural level of a people are very important in affecting the birth rate and density of population in a given part of the earth. Certain it is that the factors affecting population increase and density are exceedingly complex, although it seems reasonable to make some broad generalizations.

In general, regions in which hunting, herding, logging, forest agriculture, and other primitive occupations are widespread have low densities of population. On the other hand, those regions where agriculture is favored by the combination of soil and climatic conditions and where the industrial revolution has been experienced can support relatively high densities of population.

Regions of Dense Population. The regions of the world having extensive land areas and dense population include southeastern Asia, western and central Europe, and the northeastern United States. Small regions of dense population include Java, the lower Nile Valley, southeastern Brazil, and the vicinity of certain cities like Buenos Aires and Los Angeles. The large populations of India, China, and Japan are the result of favorable geographic conditions, particularly of the seasonal rainfall and adequate growing season of the monsoon climate, together with the fertility of the soil. These favorable conditions permit the growing of two food crops annually and in particular the production of large amounts of rice, a matter that was discussed in an earlier chapter. Java is favored by exceptionally fertile soils and other conditions of benefit to crops. Irrigated lands having a long growing season, like the Nile Valley and southern California, can support dense populations by means of agriculture. In the mid-latitudes of Europe and the United States where dense populations are found, the regions have advanced because of the combination of the industrial revolution and favorable conditions for agriculture. The presence of mineral wealth, productive soils, favorable climate, access to the sea, and other factors, including the ability and energy of the people, have contributed to rapid increase of population in the last two centuries; this in turn has led to the spectacular growth of cities.

In a large country of dense population, the people are as a rule unevenly distributed. In China, India, and Japan the fertile lowlands may support more than 1,000 people per square mile by means of intensive agriculture. The Indus Valley, the Ganges delta, the North China plain, and the Kwanto Plain near Tokyo represent this condition. The land adjacent to these densely populated rural regions may be less favorable for farming and unable to support large numbers of people per square mile, in part because of antiquated methods of farming by hand. In the Orient, farmers use hand methods of tillage and harvesting and can care for only small farms by these methods; in order to get the maximum production per acre, they must cultivate very fertile land, since there is just as much work involved in the cultivation of good land as in the cultivation of poor land. By means of mechanized farming, inferior land could be used if large units were available, but this method has not been introduced into the Orient. Only countries or regions that are small enough to have uniform conditions of farming and have no major city display even distributions of population.

The most complex phases of human activity are related to advances in the use of the products of mining, for these lead to the development of large-scale manufacturing involving the invention and fabrication of elaborate and costly machines. Only a few parts of the world have attained a manufacturing

economy. The two outstanding areas are the American manufacturing belt in the northeastern United States and southeastern Canada, and parts of northwestern Europe in the British Isles, France, Belgium, the Netherlands, western Europe, and the Soviet Union. Outlying centers are located in Japan, India, and China. There are numerous manufacturing centers in the Southern Hemisphere; but they are mostly small, partly because of the relatively small population and the distance from consuming markets.

Regions with Low Density of Population. The world contains numerous unpopulated and thinly populated regions. Among the causes for small population density are climate (cold, lack of rainfall or other water, extremes of temperature, and high humidity together with heat), roughness of the surface, and sterile soil.

The least populated parts of the earth are those having such low average temperatures that sources of human food are almost entirely lacking, namely, the antarctic continent and the interior of Greenland. Altitude as well as latitude may preclude dense population. Tibet, lying higher than 10,000 feet above sea level, has such a rigorous climate that few people can live on the meager resources provided by the elevated plateau environment. Because of their climatic conditions, the glacier-covered regions, high rugged mountains, and very elevated plateaus are the parts of the earth most inimical to human residence.

Next in order, the most hostile environment is represented by the vast oceanic expanses, which are also notably deficient in human food, with the exception of fish. Nevertheless, at any given time, thousands of people live on the oceans for varying periods, while engaged in marine activities or travel. Too much water is detrimental to human existence, but so is too little water.

The dry deserts of the world are very sparsely populated, except in those fortunate oases where water from some steady source (often outside the desert) may be obtained. It has been truly said, "The deserts are the gaps in the world's civilization." Those dry deserts which are least habitable include the largest—the Sahara—as well as Arabia and central Australia. Slightly more useful to man and somewhat more populated are the Thar of northwestern India, which has been reclaimed in part by irrigation works and thus supports a moderate population; the coastal desert of northern Chile and southern Peru, which locally can obtain water from Andean streams; the Kalahari of southern Africa, which receives slightly more rainfall than the other regions; and the Colorado or Sonoran desert of southwestern North America. In general the mid-latitude deserts of the Great Basin, the Caspian Basin, The Gobi, and the Takla-makan are relatively unused by man, since they fail to provide him with adequate water or food.

Some parts of the earth experience the opposite extreme of deserts, namely, an excess of water and woody vegetation, which combine to make life difficult for man. Much of the Amazon Basin, the Congo and Niger basins, and most of the lowland areas of the East Indian archipelago are too difficult to penetrate and remain unpopulated and only partly explored. On the other hand, some parts of southeastern Asia that receive annual rainfall greater than that of the Amazon and Congo are densely peopled because the rainfall occurs seasonally, leaving a time each year when grain crops like rice may ripen, and providing conditions more favorable to man than where the rains continue throughout the year.

World Population. In terms of the continents, population distribution is extremely uneven. Approximate figures for each continent are given in Table 6, although the figure for Asia may be unreliable because of lack of adequate data on the population of China and several other countries.

The reasons for this unequal distribution are partly geographical and partly historical. Obviously Antarctica is unpopulated because of its adverse climatic conditions, while Aus-

TABLE 6. ESTIMATED POPULATION OF THE CONTINENTS

Continent	*Population*
Asia, including U.S.S.R.	1,326,000,000
Europe, excluding U.S.S.R.	403,000,000
North America	184,000,000
Africa	157,000,000
South America	88,000,000
Australia and Oceania	11,000,000
Antarctica	—

tralia is relatively unpopulated because it has been opened to white settlement but a short time and nearly half of it is desert. Another factor enters here, less easy to evaluate; some types of men are incapable of reproducing in sufficient numbers or are unable to cope with unfavorable environments. These include the Bushmen of South Africa, the Pygmies of the Congo region, and some of the American Indian tribes. Eventually they lose their identity as more competent newcomers occupy their lands and increase in number.

It would be a mistake to assume that the present world population map is stable. Rather it is dynamic and changes constantly, though some parts are more stable than others. People move from place to place, thus redistributing human residence and activity to new and possibly unpopulated parts. Following closely upon the period of the great explorations by sea in the sixteenth century, Europeans moved by thousands and millions to the New World to form permanent settlements, thereby adding greatly to the total population of North and South America. A similar move took place in Australia in the eighteenth and nineteenth centuries. A more recent example is the migration of 30 million Chinese into Manchuria in the last 50 years. The industrial revolution contributed to the great increase in population of many regions, for example, northeastern United States, west central Europe, and many urbanized areas in Japan and many other parts of the world.

Obviously these movements revised the world map of population distribution. More violent redistribution occurs during wars or as the result of crop failures, inadequate water supply, or failure of forage supplies for animals. Abnormally low periods of rainfall may result in major population movements or in serious decline in total population of an area. This was the apparent cause of many changes among the native Indian tribes of the southwestern United States, and in part it accounts for loss of population on the northern Great Plains between 1920 and 1940.

Migrations. Migration of peoples has occurred from the dawn of tribal man to the present. Methods of transportation play an important part in the redistribution of the world's people through migration. The migrations of tribesmen of the central Asian steppes are of necessity slow if they must move on foot, and the territory they occupy is limited in extent by the mode of transport. The situation is eased if the people are able to make use of simple carts and draft animals, but only if the mass movement takes place on terrain of low relief or if well-marked roadways and passes can be utilized. Migrations over larger areas may be carried out if swift animals like the horse or the camel are available. Migrations, with the accompanying redistribution of the population, may be of several types. Whole agglomerations, such as villages or religious groups, may move en masse; on the other hand, the move may be accomplished by a slow infiltration of individuals or families, without reference to any group movement. The first type of population movement is represented by the settlements of Mormons in Utah, of Dukhobors in the plains provinces of Canada, or of Germans at Llanquihue in southern Chile. Occasionally these movements may be fostered by government action, especially if it is desirable to obtain settlers for a newly opened frontier. This was the case in Chile.

Infiltration of individuals and families brings about a redistribution of populations when the prospects of increased wealth or better living conditions lead to migrations. Boston's population was considerably increased during the nineteenth century by an infiltration of Irish, partly because of serious crop

failures and food shortages in Ireland. California's population increased greatly through a 5-year infiltration of miners following the gold rush discoveries of 1848 and 1849. By means of either mass movements or infiltration, it is possible to establish populations thinly on the world's frontier areas and to change a frontier of low economic level to more intensive human use, making it a productive region with generally improved standards of living.

Notable changes in population occur when frontiers are opened to settlement. Among examples are the Boer treks in South Africa, the opening of the Caspian steppe lands, the swarming of Chinese into Manchuria, and the settling of the Argentine Pampas and the Great Plains of the United States and Canada. For a time in the fifteenth and sixteenth centuries all of North and South America were frontiers, open to exploitation and settlement. Gradually the best outlying lands were occupied, and today there are relatively few frontiers that will provide adequate support for many people. Among those lands still available are the Peace River section of Canada, which remains relatively unpopulated; parts of the Orinoco plains in Venezuela and Colombia; some of interior Brazil; some highland country in Kenya and Tanganyika in East Africa; and portions of interior Asia.

Distribution of Population in North America. In the *United States,* most of the people live in the humid eastern half of the country. The population, along with the rainfall, declines noticeably westward from about the 98th meridian, and it then becomes dense again in the lowlands of southern California, the Great Valley of California, and the Willamette-Puget lowland of western Oregon and Washington as far north as Vancouver, British Columbia, across the Canadian boundary. Between the west-coast valleys and the eastern humid regions in the United States, there are extensive areas of population concentration in irrigated lands, as in eastern Utah and southern Idaho or on the wheat lands made cultivable by increased rainfall, as in eastern Washington and northern Oregon. Clusters or concentrations of people in much of the eastern part of the nation are largely the result of city growth and the development of centers of manufacturing. The rural population is spread rather evenly over the plains and the rolling hills, though the population tends to be sparse in the mountain areas, like the Adirondacks, the coniferous forest regions of northwest Maine, or Upper Michigan. It also tends to be sparse in undrained swamplands like those of the extreme eastern seaboard or the Everglades of Florida.

In *Canada* the brief growing season limits agricultural settlement in the northern direction, and most of the Canadians live in the Ontario peninsula, the St. Lawrence Valley, and the maritime regions near the international boundary and along the fertile plains of the prairie provinces in the interior. North of Lake Huron and Lake Superior, on the Laurentian upland, a thinly populated wilderness separates the wheat lands of the prairies from the general farming and industrial sections of eastern Canada. In both the United States and Canada the cities are located principally in the eastern parts of the countries, especially in those sections which are engaged in manufacturing. Factors affecting urban location and growth will be treated in the next chapter.

About two-thirds of *Mexico's* population and that of Central America live in the cooler healthier uplands in preference to the lowlands, a condition directly opposite to that of the mid-latitude lowlands.

Population Distribution in Europe and Other Continents. The zone of dense population in *Europe* extends from England through northern France, Belgium, the Netherlands, central Germany, western Czechoslovakia, Poland, and into the Ukraine of southern U.S.S.R. Within this zone is a combination of geographical factors suitable for the advances of industry, including coal deposits, access to consuming markets, presence

of raw materials for manufacture, fertile soil, and an early start in manufactures; all these led to a great increase of population and urbanization, especially during the past century. In southern Europe dense populations are local rather than arranged in a long zone; these clusters of settlement are usually found in deltas, along river valleys, and in coastal zones. The Po Valley, outstanding among them, combines agriculture and industry within its limits. The coast of eastern Spain near Barcelona, the Naples area, the district around Saloniki in Greece, the Lyon-Marseille cluster in France, and the vicinity of Istanbul are among the important minor concentrations of population.

Asia, except in Japan, has been only slightly affected by industrial development. On this continent most of the areas of dense population coincide with locations of intensive agriculture, with the extensive thinly peopled areas devoted more directly to herding, forestry, and a little subsistence farming. The introduction of mechanized farming methods would make possible some extensions of farming into the grasslands of Asia and in all probability would lead to a corresponding increase of population in that part of the world, provided that satisfactory methods of transportation were installed by which export crops of wheat could be marketed.

In tropical *South America* the densely populated areas are in the highlands, as in Central America and Mexico, but in the southern part of the continent in the mid-latitudes the inhabitants are concentrated on the lowlands, which are favorable for agriculture. Mountains, forests, and dry grasslands toward the southern tip of South America are able to support few people compared with the Pampas near Buenos Aires, the rolling plains of Uruguay, or the central valley of Chile.

In *Africa* the concentration of population occurs principally near the Mediterranean Sea, in Nigeria and West Africa, in the highlands of East Africa, and in the southern and eastern parts of the continent. Among the very dense populations existing by means of agriculture are those of the delta and flood plain of the Nile River, with 1,500 people per square mile in its lower part; this density contrasts sharply with the adjacent deserts, which are almost devoid of residents.

A large part of *Australia* is almost empty of people, but there are some concentrations in the southeastern part around Melbourne and Sydney, and moderate population along the Queensland coast and in the southwest.

Problems

1. What are the principal human economies?
2. What is an extractive economy?
3. Why do men persist in occupying unfavorable environments?
4. List some of the advances that have made possible the utilization of (*a*) lands in the hot humid regions, (*b*) lands in the cold humid regions, (*c*) lands in the hot dry regions, (*d*) lands in the cold dry regions.
5. Each of the following migrations was brought about by specific causes. Examine each case and attempt to relate the causes to geographic factors: (*a*) the Turkish invasion of central Europe in the fifteenth century, (*b*) the American occupation of California in 1848, (*c*) the British occupation of Australia in the early nineteenth century, (*d*) the Chinese migration to Manchuria in the twentieth century, (*e*) the German migration to the United States in 1848, (*f*) exodus from the Great Plains in the 1930's.
6. Indicate on a map those parts of the world which you consider belong to a frontier condition as far as human living conditions are concerned.
7. What is the physical pattern of the population distribution in the vicinity of your home community? How is this pattern related to the local physical geography?

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CHAPTER 24: *The Geography of Rural and Urban Life*

Even in regions whose population is dominantly rural in character, small groupings of people are gathered together for social or economic reasons. The smallest group is the family, and it is entirely natural that it may attract other families—tribal relatives—to live nearby. Man is by nature a gregarious creature, and his dependence on his fellows for mutual defense and companionship leads him to settle near his neighbors. In a relatively short time a small node of settlement appears in a landscape, although most of the people may be living at some distance from each other. Thus a population map of a rural region may be misinterpreted, since the people are unevenly distributed; some will be occupying widely dispersed farms, while others will be clustered together in rural settlements that eventually become hamlets. These in turn may evolve into villages, towns, and eventually cities. Even so, many prefer to live apart under conditions of dispersed habitation. This is possible only when there is no threat of danger too great to be overcome by the individual or his family. The population distribution of Europe during medieval times, for example, was not widely dispersed on separate farms but was grouped in settlement agglomerations united for defense purposes and owing allegiance to professional warriors who undertook the defense of the settlement when it was threatened by aggression from outside.

Dispersed Settlements. Upon the removal of the threat of war and danger to the settlement, it became possible for individuals to establish farms at some distance from towns and fortified points, and on newly settled lands of the world this has become common practice. New England, settled during the seventeenth century, when Indian threats were serious, retained the compact town partly for defense purposes, and few dared live far beyond its limits because of the risk of attack. Pennsylvania, settled principally in the eighteenth century, was occupied by frontiersmen who frequently built their farmhouses at considerable distances from each other. At times they were powerless to defend their scattered farms, as they learned bitterly during the Wyoming Valley massacre in 1778.

As a rule, dispersed settlements are found today in the great "sheep stations" of the Australian grazing lands, the ranching centers of the Orinoco Basin, and the farming and ranching sections of Texas and California. Most of these are in recently settled parts. In contrast the pueblo villages of the American Southwest (which have been described), most parts of India, China, and Japan, and those parts of Europe which experienced a feudal system have rural settlements in village form, with farmed lands and pasture separating the village agglomerations or settlement nodes. In each case the need for defense was at first an important factor in determining the mode of settlement, but now it is merely because of custom. An intermediate condition prevails in most parts of Japan and the Philippines, the forested regions of French West Africa, and the central United States, where a combination of dispersed and agglomerated populations is customary.

Farmstead Buildings. The dispersed farmstead, so common in the American landscape east of the Rocky Mountains, varies widely in its physical arrangement and in the different elements comprising it. Farmhouse and barn are essential structures, varying greatly in size and quality, and reflecting strongly the human activities to which they are related (Fig. 109). New England hill-

country farmhouses, low and rambling, connected with their barns by a weatherproof covered passage, indicate the severe winters prevailing in that region. Two-story Pennsylvania farmhouses of brick or stone, built substantially to withstand cold winters and hot summers, contrast sharply with frame rural houses of the southern states, where insulation against cold is unnecessary most of the year.

Barns, even more than houses, indicate geographical conditions. Those of the humid continental regions must be solid and warm; and, if care of livestock is part of the farmer's activities, the barn must be large enough to house them, along with a large supply of winter's feed. Many barns in the eastern United States are designed to take advantage of hill slopes and may be entered on two levels; these are known as "bank barns." In those parts of the country where winters are mild, barns need not be large or substantial but may resemble temporary sheds. If it is located in a climate where stall feeding of cattle is needed during long cold winters, the barn may have one or two silos attached; but, in the South, West, and Northwest where no month in the year has temperatures averaging less than 32°F., it is possible to pasture cattle almost all year long in the open, and silage is not necessary for feeding. In the central parts of the country, the corncrib—a structure of Indian origin—is a necessary part of the farm complex, but this is not usually found in the Far West or the Pacific Northwest, where the corn crop is unimportant. Its size often indicates the productivity of the farmer's land. Outbuildings for the storage and repair of farm machinery, hogpens, poultry houses, and a wide variety of other structures are indicators of human activity on dispersed farmsteads of the nation.

Growth and Characteristics of Villages. Often the establishment of a farm or two in a favorable location attracts other farmers or ranchers, and a settlement node begins to take form. In the open plains of the western states, single cattle ranches evolve into settlement units. Sometimes the beginnings of settlement are relatively vague, consisting of loosely related farm establishments belonging to members of the same family. It is not unusual to find settlement names attached to a hamlet that may be made up of only two or three farmhouses. From these beginnings, an agglomeration occurs, and shortly it is possible to discern village functions making their appearance—mutual efforts at fire protection, a voting precinct, legal authority, and later, when population has increased, health protection, sewage disposal, village officials, community recreation, a public library, hospitals, and a post office.

Towns and villages, even though established for purposes of defense, commonly lose this function as they become mature settlements. This may occur upon completion of a major political or economic change, especially as frontier conditions of settlement become stabilized. Thus we have ancient settlements marked by relic forts, bastions, castles, and walls, enclosing the kernel of the original agglomeration (Fig. 251); upon removal of the need for protective structures, they fall into decay as the village grows and spreads beyond the original walls into surrounding country that originally lay well outside the protected area. This type of development is especially conspicuous in Europe, but some settlements in North America (Quebec, Sacramento) have evolved on this pattern.

Frequently the old-time European and American village settlements were haphazard in their growth, with very narrow streets or alleys, winding roads, and relatively small property holdings. Often the village streets evolved along unplanned and unsurveyed country roads, particularly at crossroads or road junctions. This gave rise to some slight patterning of the streets, thus providing different physical characteristics of the towns. Sometimes the crossroads type became a cruciform village, and the village situated at a road fork became Y-shaped in its major pattern. Other villages, often very ancient, took on a circular pattern whose principal feature

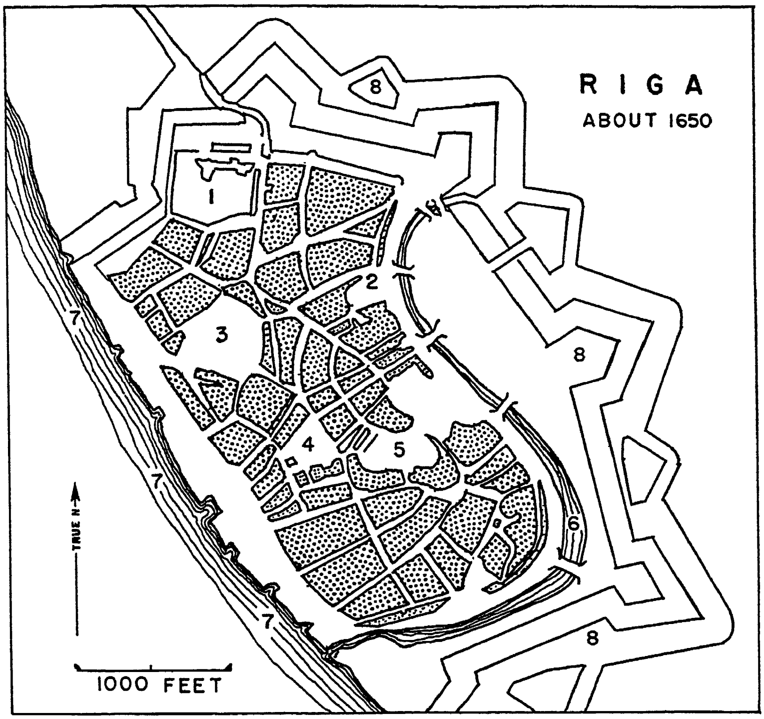

Fig. 251. Riga, Latvia, an unpatterned town within a pattern fortification. 1, nunnery; 2, gildhouse; 3, cathedral; 4, town hall and market place; 5, cathedral; 6, Rigebach, a tributary of the Duna; 7, the Duna; 8, fortifications. *(Used courtesy of J. B. Leighly.)*

was an encircling street surrounding the whole settlement. One common type was the simple "string town," or street village, consisting of two long rows of houses facing each other on either side of a "main street." Still another pattern centered around a village square or "common"; this type was especially characteristic of towns established by the colonists in New England. Radial town patterns are often associated with road crossings, and they represent a concentration of routes of travel. They are found occasionally among older American settlements but have never been common, since they produce traffic problems and landholdings that are of odd size and shape.

The Growth of Cities. The remarkable increase in the number and size of cities in modern times is the result of great changes in manufacturing and transportation from the old days. In ancient times an empire like that of Rome could support only its capital and a few commercial centers, the latter usually being seaports. With the primitive methods of agriculture, most of the people were subsistence farmers, and few cities were needed or could be maintained. During medieval times, conditions deteriorated, and cities were few and small. Men gathered together in villages and little self-sufficient towns for mutual aid and protection, but the big city that depended upon food and other supplies from distant places was of rare occurrence. The economic revolution and revival of commerce helped city growth, but as late as 1800 there was not a single city in the United States of 100,000 people and only a few such in all of Europe.

The large number of cities in our time stems from the industrial revolution; for, without the steamships, railroads, and trucks, the enormous populations of urban centers could not receive food or raw materials for manufacture or the many other things they con-

sume or require. Without the invention of machinery for manufacturing and the development of commerce, the people of cities could not find remunerative occupations. Today half the people in a new country like Australia live in the capital cities of the six provinces of that commonwealth. In the United States more than half our population is classified as urban by the census reports; that is, more than half the people live in towns of more than 2,500 population. Economic affairs in the United States, western Europe, and other parts of the world with Western civilization or industrialization are dominated by the cities.

It should be made clear that, when a geographer refers to a "city," he is applying the term to the metropolitan area, which includes the suburbs used for industrial and residential purposes, nearby towns, and outlying districts which logically can be included in one urban center.

The Location of Cities

Great cities of the world tend to develop at certain favorable locations, especially where several geographic factors contribute to urban growth. Favorable locations include those of level site, accessibility to productive trade areas, convenient natural resources for manufacturing, sources of power, and a healthful location from the standpoint of human energy.

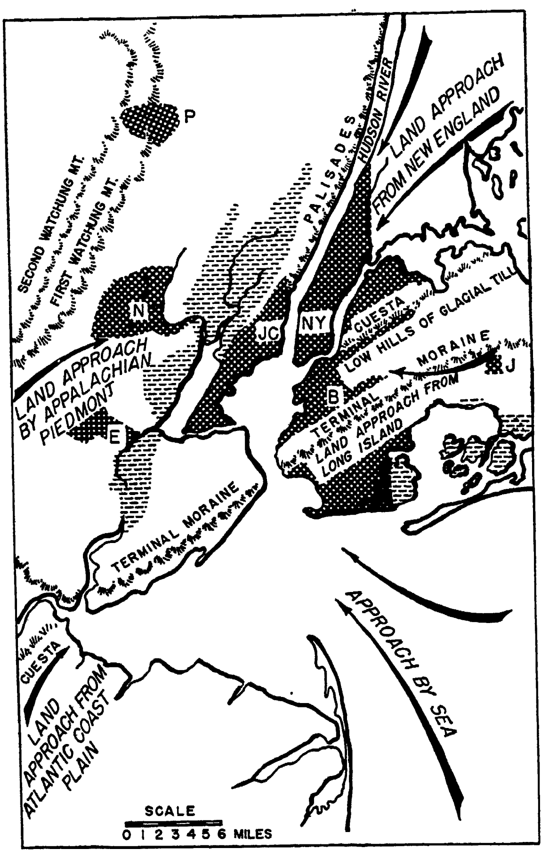

FIG. 252. New York as a focal center for transportation routes. *NY*, New York (Manhattan); *JC*, Jersey City; *N*, Newark; *B*, Brooklyn; *J*, Jamaica; *P*, Paterson; *E*, Elizabeth. (*After Carl O. Sauer.*)

Relation of Cities to Their Sites. The site on which a city is built should be well located in respect to favorable factors for its growth and also where there is plenty of room for expansion and development (Fig. 252). Cities built in level terrain can be more easily and cheaply provided with streets, transportation, water, sewers, and other facilities than can those located on hills, in narrow valleys, or on small islands. Cities at the junctions of railroads, at the head of ocean navigation on rivers, at the confluences of rivers, and on the shores of the Great Lakes served by rail or canal routes possess obvious natural advantages, especially if the terrain is smooth so that there is room for expansion. On the other hand, the sites of some cities are handicaps to the construction of buildings and the provision for facilities for many people. Pittsburgh and San Francisco are hemmed in by hills (Fig. 253), New York proper is restricted to an island, Seattle was built on a hilly site between a large lake and Puget Sound, New Orleans was started in a swamp, Mexico City is on an ancient lake bed underlain by quicksand, and Venice grew on little islands and offshore shallow banks.

The direction of growth in a city is strongl

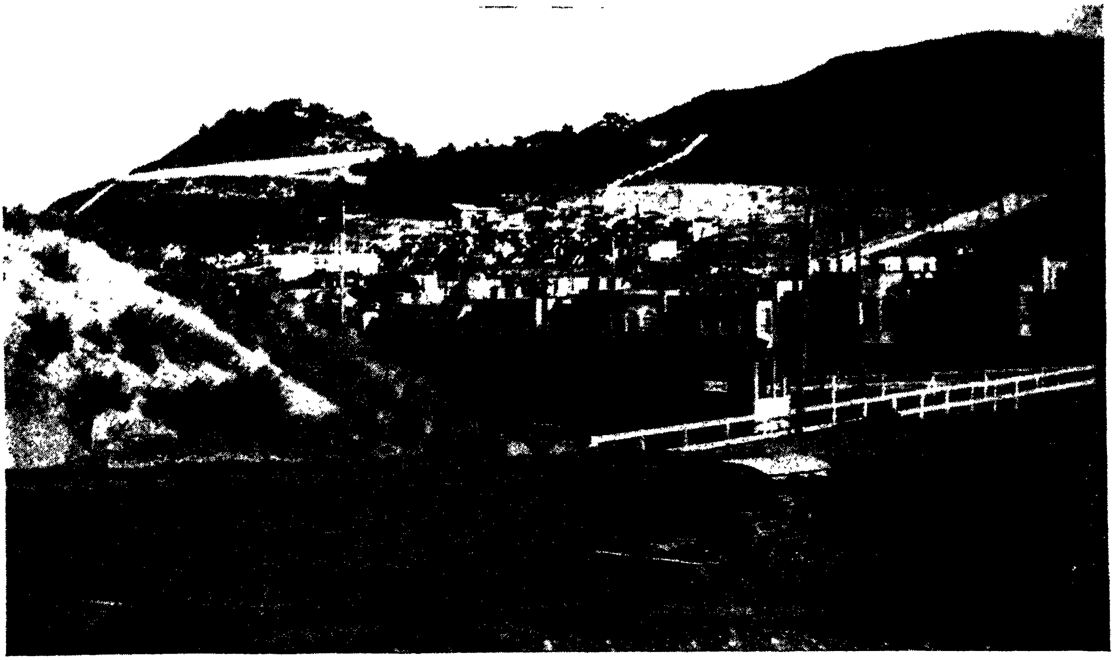

FIG. 253. Active sand dunes in the western part of San Francisco being transformed into city building lots. Note the extremely unconsolidated nature of the dune material. Typical San Francisco houses in middle distance; large bay windows are characteristic of San Francisco residences.

influenced by various factors, including the physical features of the site; transportation routes; location of factories or other sources of smoke, odors, and noise; zoning restrictions; and private or public direction. San Francisco, originally built around a small cove and almost entirely surrounded by steep hills, has partly freed itself from its geographical restrictions by the construction of its two large bridges across San Francisco Bay and the Golden Gate. A 2-mile tunnel for electric streetcars cut through Twin Peaks opened new land for residence by reducing the time needed by commuters to travel from their homes to their work in the commercial core of the city. The great railroad and vehicular tunnels and bridges in New York City encouraged the dispersal of city workers into less congested districts of the Bronx, Long Island, and the Jersey shore. The subway in Chicago, when extended, will make new residential areas available by providing more rapid transportation.

Cheap transportation is vital for success in selling bulky products in distant markets and hence is an important factor affecting city growth. Seaports, lake or river ports, and rail centers have an advantage in this respect. In these locations the manufacture of raw materials and the shipment of finished articles are convenient. Naturally these help the growth of the cities concerned. Some industrial cities have been founded by corporations near new manufacturing plants located at favorable sites, like Gary, with its steel mills on Lake Michigan, and Longview, Washington, with its sawmills on the Columbia River. These towns were planned and laid out in advance of construction or occupation, and their transportation facilities are advantageously arranged.

More often, however, industrial towns just "grow" without any consistent plan. Once these cities start to grow, factories of various types are needed to help supply food, shelter, and other consumer goods demanded by the

inhabitants; further, the abundance of labor and capital available in any city is a factor contributing to its growth. Some cities gain a special reputation for manufacturing a certain product—men's shirts, for example—and a capitalist who wishes to engage in that industry may elect to start his plant in a center already famous for the product because buyers are accustomed to come there to purchase that particular commodity. Furthermore he can obtain skilled labor easily.

Effect of Transportation. Factors of transportation exert the most effective influence on the growth and development of urban centers. In fact, without adequate transportation, no populous center can exist. Many cities began as mere crossroad trading centers. Transfer of commodities from one form of transportation to another is a common necessity; thus there are the farm-market towns in which the farm products are hauled in by wagon or truck and shipped by rail or boat to the more distant terminal points. The junction of railroads, division points, and location of car shops all give employment and add to the population of cities. Cities develop where there is a transfer from one form of transportation to another, especially when bulky commodities are being handled. This is known as "breaking of bulk." Thus Duluth receives wheat, flax, lumber, and iron ore by rail and then ships these products down the Great Lakes by steamer. In return, coal, automobiles, and some other manufactures are brought to Duluth for distribution inland by rail from the steamer docks.

Intersections of railroads, highways, or waterways with the same or different forms of transportation are always favorable to the growth of cities. Natural relief features may control transportation routes and hence the locations of towns. In Europe intersection of trade routes accounts largely for the growth of Berlin, Moscow, Vienna, Paris, and London, though military activities were also an important factor in the establishment and growth of all these centers. In North America good examples of transport centers include Chicago, St. Louis, Kansas City, and Montreal, Canada.

Cities Located at River Sites. Before the development of railroad transportation, important cities of necessity were either seaports or were located on navigable rivers. Most large European cities are seaports or river ports. Every capital city of the 18 original provinces of China is said to have been built on a navigable stream. Even with the decline in river traffic on most streams in the United States, many cities owe their start, if not their continued growth, to a river location.

Several locations on rivers have special advantages, as at the mouth of the stream or as near the mouth as may be convenient for ocean and river boats to exchange cargoes. This type of city site is represented at New Orleans and at Portland, Oregon. Another favored site lies at the head of upriver navigation, determined by rapids, falls, or decreased depth of the water. Fort Benton, Montana; Sacramento, California; and St. Paul, Minnesota, as well as many fall line cities along the Atlantic seaboard, typify this location.

Another favorable location lies at the confluence of two streams that provide routes in three directions, as at Pittsburgh, St. Louis, and Cairo, Illinois. Of necessity the ground at the junction of rivers should be high enough to provide a city site above floodwaters. Some streams join each other in low swampy land that is entirely unsuited for building purposes, and at these sites no cities of importance can be built without major readjustments. The junction of the Red River and the Mississippi, or the Arkansas and Mississippi, for example, is unsatisfactory for building purposes, and neither confluence is occupied by an important town or city. Rivers may erode the ground at their confluence; the site of the old trading post of Fort Union, located at the junction of the Yellowstone and Missouri rivers a century ago, has entirely

disappeared, and the mouth of the Yellowstone is nearly 5 miles away from its former location. Such conditions are not conducive to the establishment of a large city or even a successful village.

Important river ports should have deep water close to shore. A favorite site usually is found on the outside of bends at the base of cliffs, where the river in its meandering course is undercutting the upland at the site of the city (Fig. 160). These locations account for the principal cities and towns between New Orleans and St. Louis, including Baton Rouge, Natchez, Vicksburg, Memphis, New Madrid, and Cape Girardeau.

Another important location lies at any break in transportation that may result from falls or rapids around which goods must be portaged, as at Louisville on the "Falls of the Ohio," and The Dalles, Oregon, on the Columbia River. Other towns are at convenient junctions of canals and rivers, as at Albany and Troy, New York, or of land routes and water routes, as at Cincinnati and Kansas City. Manufacturing towns, as mentioned previously, developed quickly at sources of water power, as at Minneapolis (Fig. 254), Spokane, and Holyoke. Early trading towns along the Ohio River include Marietta and Portsmouth, Ohio; Madison, Indiana; and Paducah, Kentucky.

Sometimes "twin cities" develop, one at the head of navigation and the other at the rapids, as at St. Paul and Minneapolis. Twin cities may also develop on opposite sides of rivers or bays. As a city grows, those who wish to practice gardening or poultry raising may live on the other shore where land is cheap. Factories may also be located opposite the big city on the cheaper building sites available. Twin cities having these characteristics are numerous: St. Louis and East St. Louis; Kansas City, Kansas, North Kansas City and Kansas City, Missouri; Cincinnati and Cov-

FIG. 254. Modern flour mills and grain elevators at Minneapolis, Minnesota. Storage bins for grain appear at the right and flour mills in the center. (*Photograph courtesy of Minneapolis Grain Exchange, from George Miles Ryan Studio.*)

ington; Detroit and Windsor; New York and the Jersey shore cities; San Francisco and Oakland.

If the river has an extensive bar or delta at its mouth, it may be impractical to locate a seaport there. In that case the seaport usually lies along the coast as near as possible to the river route: Marseille near the Rhone, Alexandria near the Nile, and Constanța on the Danube.

The Functions of Cities

Cities have many different functions; sometimes none is particularly outstanding, but in other cases certain functions are conspicuous in the life of the city. Among the more important functional types of cities are those devoted primarily to commerce and trade, manufacturing, transport; political, religious, and educational centers; health and pleasure resorts; and those producing such natural commodities as coal, iron, lumber, or fish.

Commercial Cities and Trade Centers. A commercial city above all else must have convenience of transportation. An ideal location is on a good harbor with easy access by river or rail to a rich hinterland or tributary territory. The great commercial cities like New York (Fig. 252) and London are favored by their locations along the main world trade routes. Human factors often aid the growth of commercial centers; thus Hong Kong and Singapore, developed by the British from mere villages to large cities in a single century, are free ports and have become great entrepôts where goods are assembled from all parts of the world and then redistributed to other markets. If the islands on which Hong Kong and Singapore are located had remained under the control of the Chinese and the Malays, respectively, their development would have been greatly retarded. Some inland cities like Chicago and St. Louis are also of great importance for commerce, although less favored than ocean ports, which have advantages of both domestic and foreign trade. Commercial cities provide much employment to those engaged in transportation and the wholesaling of goods.

The inland trading center may vary in size from the rural crossroads village, with its general store, filling station, and blacksmith shop required by farmers, to cities of several hundred thousands of population. Rural residents buy foodstuffs, small utensils, and minor necessities from the nearest little trading center, but larger purchases are more often obtained from the larger town. The development of the automobile in the United States made it possible to drive 50 miles in the same time that five miles could be traveled by horse and wagon. Many buyers prefer to go to the larger centers to get house furnishings, women's apparel, or other high-priced merchandise because the range of selection is greater in the larger stores than in the small towns. As a result, within an increasing radius around the cities, the populations of minor trading centers have declined, although those places near the larger cities may have grown because of their increased use as places of residence by men who work in the cities.

Industrial Cities. Cities become important for manufacturing as the result of a combination of natural and human factors. A well-managed plant located near markets and sources of raw material succeeds and by providing employment aids the growth of a city; but a factory established in defiance of geographical principles, at a distance from markets, using materials from distant regions, is handicapped from the start and will probably fail. Competition is tremendously keen in industry, and the human factor of management is very important. Of hundreds of concerns that once made automobiles, a half dozen now manufacture the great majority used in this country. At Battle Creek there were once dozens of breakfast-food factories, but now only two large firms handle the business there. Some factory towns were deliberately selected with an eye to natural advantages favorable to

FIG. 255. Commercial core of Youngstown, Ohio, a highly industrialized city specializing in iron and steel products. Note the bridges spanning the Mahoning River, the constricted location of rail lines parallel to the river, and the presence of steel mills at right. (*Photograph courtesy of the Youngstown Vindicator.*)

a certain industry. Thus Birmingham in Alabama has self-fluxing iron ore and coal close together and was chosen for the site of blast furnaces and steel mills. A steel mill requires a large space for the plant, and often the preferred location is a site near a large city but on cheaper ground outside the city limits (Fig. 255). Thus Pittsburgh is surrounded by many minor iron smelting and manufacturing centers: Carnegie, McKees Rocks, McKeesport, Braddock, Homestead, and Duquesne. When a new steel plant was needed near Chicago, a site at Gary among the Indiana sand dunes was selected, where ore brought down the Great Lakes met coal at the lakeside.

As has been mentioned, many manufacturing centers became large cities because of the growth of one or more industries originally started by the accident that an inventor lived there, or because a small industry begun by someone for no particular reason by luck or good management developed into a successful business. Among many examples that might be mentioned of this type are automobiles at Detroit; tires and other rubber goods at Akron; optical goods at Southbridge, Massachusetts; cameras at Rochester; washing machines at Mason City, Iowa; and cash registers at Dayton.

The presence of coal, oil, gas, or water power to furnish energy for industries is always an attraction to manufacturers and therefore greatly helps the growth of cities. Without a source of power at a reasonable price, large-scale competitive manufacturing is obviously impossible; nearly every important industrial city in this country is an example. Only in an industry like optical goods, watches, or scientific instruments made in Switzerland, where skill is more important than raw material and power, is this factor unimportant.

Railroad Cities. Railroads have been prolific causes for the location and growth of cities in the United States and in other new countries like Canada, since the railroad often preceded settlement in the middle and western parts of these nations. Among the natural factors involved are the ends of barriers, like lakes, mountains, arms of the sea, or deserts; the ends of passes; natural crossings or junctions of routes; or any natural break in transportation en route and at terminal points (Fig. 256). Often the selection of one of the possible routes for the line or location for a station determined which of several centers would develop into important cities and which would languish for want of trade. During railroad-building days, the construction town at the constantly extending end of the line enjoyed a temporary boom. Similar construction towns develop during the building of dams like Hoover and Grand Coulee, tunnel jobs like the Metropolitan Aqueduct at Los Angeles, and sometimes highway jobs and war-training centers.

The railroads themselves were built first from city to city, often to connect two waterways, and were located along previous routes of travel. Thus they helped the growth of cities already established and extended markets for factories and other producers in the area. Generally a railroad builds on the easiest route available where population and freight are at hand. Sometimes a railroad must cross rather unproductive territory like Nevada in order to connect developed regions like the Middle West and the Pacific coast. Thousands of new towns developed along the rail lines as they were built in the United States. No important city is without railroad service in this country.

Political Cities. Cities selected as provincial or national capitals have an advantage over towns lacking this designation, since numerous employees are used in clerical and admin-

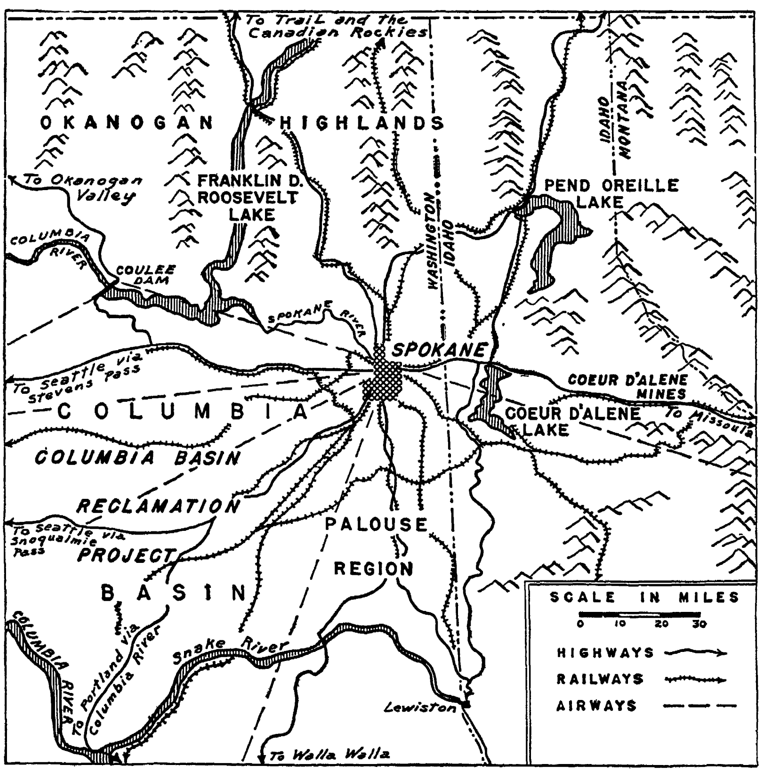

FIG. 256. Spokane, Washington, as a center of rail, highway, and air transportation routes.

istrative work, and usually a political capital is also a social center. In general a capital is located at a convenient point near the center of population more often than in the middle of an area. Washington was selected at the head of navigation on the Potomac River, from which George Washington anticipated canals would be built over the mountains to the tributaries of the Ohio River. Its site was nearly at the center of the 13 original colonies and was then close to the center of population. The capital of the United States, if a new site were to be selected now, would no doubt be west of the Appalachian barrier in a location less exposed to attack by sea and more accessible to the great number of residents of the nation. It is interesting that when a site was chosen for the building of vaults for storing the gold reserve of the national government, the place selected was in the state of Kentucky.

Sometimes one city of a nation, like London or Paris, has such overwhelming importance compared with others that it seems natural for it to become the capital. On the other hand, Madrid, with no advantages over other towns in the interior part of Spain, serves as the capital of that country. In fact it is cold, dry, and dusty compared with Toledo, the former capital; yet, after the rulers chose Madrid for their capital, its importance was greatly enhanced. A similar occurrence took place at Leningrad, which was the largest city as well as the capital of imperial Russia. The site was selected by Peter the Great in a marsh along the Neva River and had few natural advantages. Under the Soviet regime, the capital of the Soviet Union was moved to Moscow, nearer the center of population in the European part of the nation, and less exposed to attack from a foreign power; Leningrad has steadily declined since the change was made.

In China, when the central government was strong and vigorous, the capital was usually located at Peking (northern capital), from which the nomads of Manchuria and Mongolia could be best controlled; but, when the government became weak and unorganized, the capital was withdrawn to Nanking (southern capital), which was less exposed to attack. Much of the northern part of the country might be abandoned to more vigorous and warlike Mongols upon occasion. The site for the Australian capital at Canberra was chosen in a healthy and picturesque basin in the interior, about midway between Sydney and Melbourne. Before Canberra was built, the location had no settlement of importance but was occupied only by a sheep ranch.

Just as Washington is now on the eastern margin of the United States instead of in a position near the center of population, so some state capitals are in corners of their respective governments. Usually this occurred because their sites were selected before the states became well settled. Thus Helena in Montana was chosen before the settlement of the agricultural eastern part of that state and at a time when mining was the only important industry in the territory. Tallahassee in northern Florida was chosen when the southern part of that state was unpopulated except for a few Indians. Salem in the northern Willamette Valley of western Oregon was decided upon when only that fertile lowland was occupied by the people of Oregon. On the other hand, cities like Indianapolis, Columbus, Springfield, and Des Moines have the advantage of locations near the centers of states—a factor that was certainly taken into consideration in their selection. Even the choice of a town as a county seat brings some employment, visitors, and growth of business and population to the community.

Pleasure and Health Resorts. To succeed as a resort city, the location must be favorable for that purpose and must be easily accessible to large numbers of people who desire and can afford recreation. Atlantic City, New Jersey, has a fine sandy beach and pleasant summertime climate; of equal importance, it can be reached with ease by rail and highway from New York, Philadelphia, and scores of other important cities. Ostend, Belgium; Brighton, England; and Nice and Biarritz in France are examples of beach resorts in Eu-

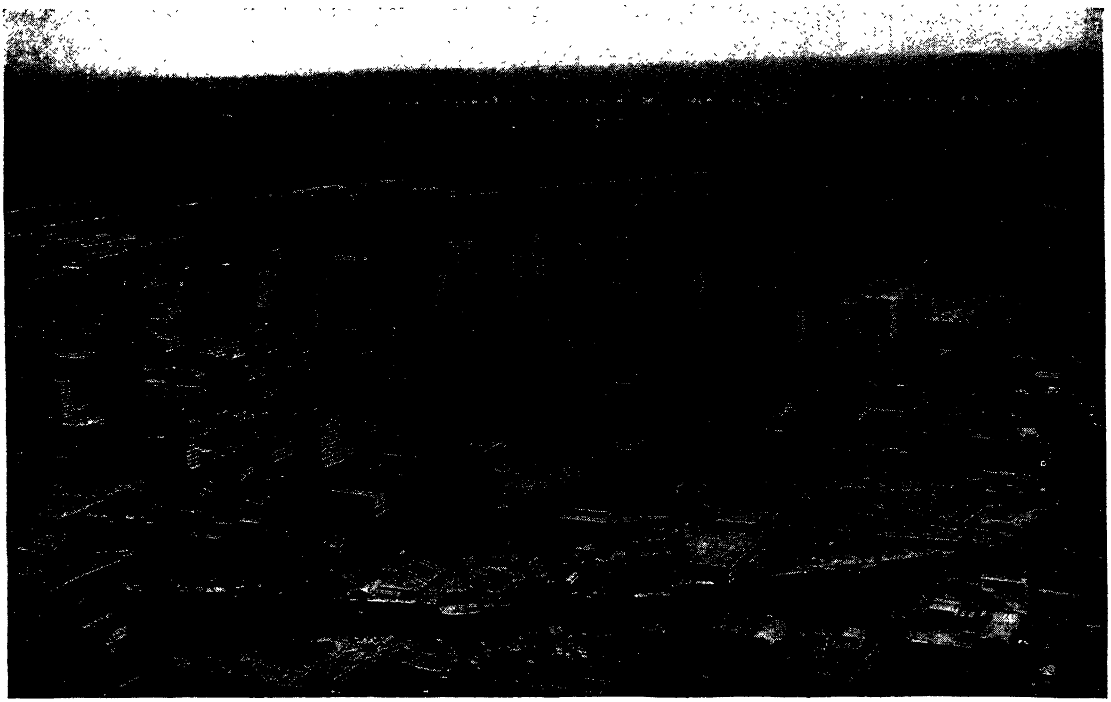

FIG. 257. Miami, Florida, with the Miami River in the foreground, the downtown business and hotel section in the middle distance, and Biscayne Bay in the background. This city owes its existence largely to the demand for tourist accommodations and capitalizes on its fine winter weather. Popular resort hotels of Miami Beach appear near the skyline on an offshore sand bar that is reached from the mainland by causeways. (*Photograph courtesy of the City of Miami News Bureau.*)

rope that are easily reached from nearby great cities. Although resorts like those of southern Florida (Fig. 257) and southern California have special climatic advantages that are attractive to people from remote places, they must be accessible to transportation in order to be used extensively. The Hawaiian Islands and Bermuda are reached readily by steamship and are good examples of oceanic resorts. In Hawaii, the "third" industry, or tourist trade, has greatly helped the growth of the city of Honolulu (Fig. 258). Some centers, like Rome, Venice, and Naples in Italy and Athens, Greece, have capitalized on the monuments and buildings of ancient times and attract thousands of tourists. In recent years, winter sports have become popular; St. Moritz in Switzerland; Lake Placid, New York; Sun Valley, Idaho; and points in Switzerland have capitalized on this new source of revenue. Pleasure resorts vary in population depending on the season of the year, since both pleasure seekers and those who serve them are mostly seasonal residents.

Some towns have reputations as health resorts; this may be the principal support of the community. It may be the advantages of sunshine and clear air, as at Colorado Springs, Albuquerque, Tucson, or Phoenix. In other cases the attraction consists of hot mineral springs from which the water may be used for bathing or drinking. Familiar examples include Hot Springs, Arkansas; French Lick, Indiana; and Saratoga Springs, New York; these resorts cater to pleasure seekers as well as to health seekers. Other less well-known health springs are found in most states of this country. Some springs, like Lourdes in the Pyrenees of southern France, have become places of pilgrimage for those suffering from disease.

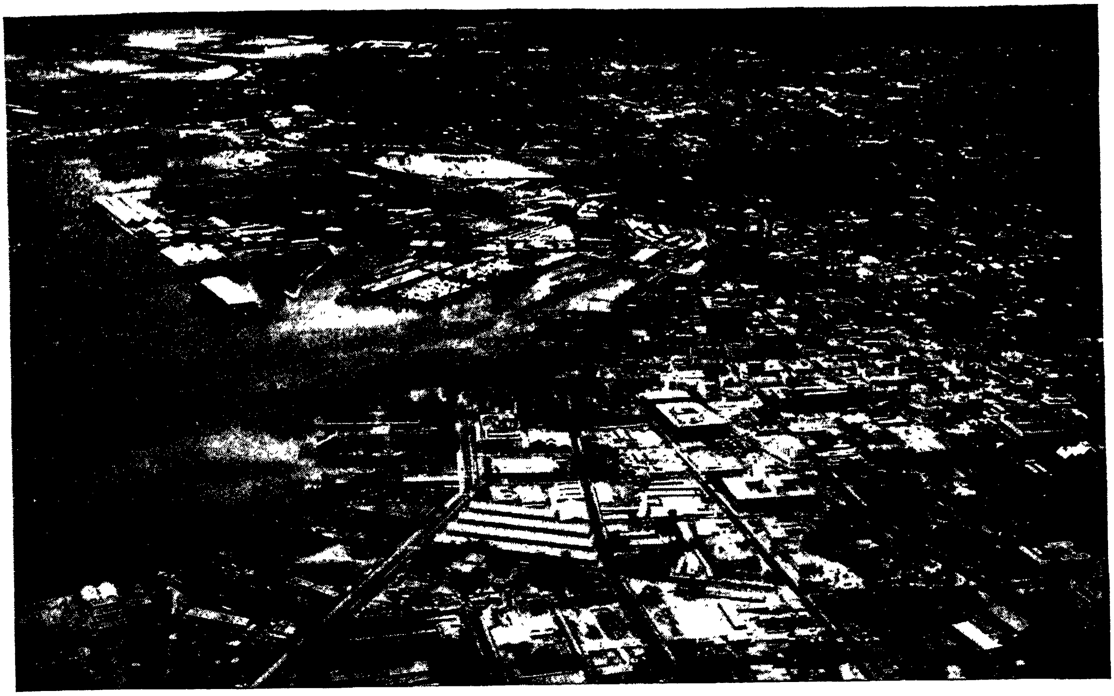

FIG. 258. The harbor of Honolulu developed largely because of its central location in the Pacific, where it serves as exporting point for Hawaiian agricultural products and as a stopping place for trans-Pacific vessels. Note assemblage of warehouses and wharves. Note also that this port, unlike most others, has no large space devoted to rail lines. (*Photograph used by permission of the Hawaii Visitors Bureau.*)

Changes in Functions of Cities. Sometimes cities outgrow the original reasons for their location; for example, Bruges and Ghent in Belgium were important ports during the Middle Ages, but their harbors silted up and they could no longer be used as ports when ships became large in size. Bristol and Plymouth in England were important ports two centuries ago, but the industrial revolution emphasized the growth of cities whose factories could be operated by coal; this created a demand for ports nearer than Bristol or Plymouth which could serve the industrial areas. As a result, Liverpool, Glasgow, Hull, and Newcastle developed into large cities while those ports which served agricultural southwestern England made relatively little progress. Cities dependent on minerals and forest products are oftentimes short-lived because of exhaustion of their raw materials unless some other industry replaces the original one; thus Saginaw and Bay City, Michigan, once famous for their lumber mills, now make automobile parts and other machinery.

Miscellaneous Factors Leading to the Growth of Cities. Anything that calls people together at a certain place may lead to the beginning of an urban community. In the Middle Ages, villagers built their houses around the base of the overlord's castle for the sake of protection. It was frequently located on a hill favorable for defense, as at Edinburgh or Carcassonne. Occasionally fortress towns still exist, a notable example being Verdun, France. Sometimes an entire city like Bremerton, Washington, may depend for most of its trade upon military or naval installations. San Diego, California, and Norfolk, Virginia, also have advanced because of their particular relationships to the Army and Navy.

Cathedrals and other religious centers attract people, and sometimes they form the urban center around which the city grows. Occasionally cities develop because they are

selected as headquarters of a religious faith, which was the case at Rome, Salt Lake City, and Lhasa. Some towns have grown up around monasteries. Certain settlements have been started by groups who wished to live together in a communal way or who gathered because of peculiarities of their religious beliefs. Summer chautauquas, camp meetings, institutes, and the like, often held at some lake or other pleasant location, may attract enough visitors to affect the growth of nearby towns.

Educational Centers. Not infrequently institutions of higher education form the principal support of the community where they are located; for example, Ann Arbor, Michigan; Urbana, Illinois; Oxford and Cambridge, England; Palo Alto, California; State College, Pennsylvania; College Station, Texas; Corvallis, Oregon; Moscow, Idaho; and Pullman, Washington. On the other hand, most large cities above 100,000 in population in the United States have from one to several colleges and universities simply because the large numbers of young people needing educational facilities have led to the establishment of higher institutions of learning.

Resource Cities. Mining, fishing, and lumbering centers resemble each other in that they collect natural products and distribute them to distant markets, with but a small amount of the products being used in the immediate vicinity. Obviously a town that is supported by the exploitation of a natural product must have a location near a supply of the article. Examples of mining towns would include Butte; Johannesburg; Hibbing, Minnesota; and the coal-mining towns of Pennsylvania. Though a mine must be near the location of the ores, a smelter or refinery may be built at sites more favorable than those which might be available in the mountains near the mines (Fig. 233). Fishing centers, as mentioned elsewhere, must be conveniently located with regard to the supply of fish, and for the sale of the product, either by shipment to the interior or by boat. Lumber centers by preference are on navigable waterways by which the sawed lumber may be shipped and the logs received.

The Factor of Fairs and Exhibits. City growth is sometimes helped by having regular market days or holding annual fairs and exhibits for the sale of goods. In a number of towns in Europe and Latin America, the open square usually left in front of a cathedral or town hall has been used as a market place. Sometimes fairs that began as a convenience for the exchange of goods led to the building of warehouses and factories and resulted in the founding of permanent trading centers. Around the Central Plateau in France lies a peripheral row of cities where the crops of the nearby lowlands were traded for the livestock products of the uplands; the locations of these ancient fairs have often developed into important urban centers. In the highlands of South America, Peruvian Indians still hold primitive market fairs at designated spots on certain days of the week or month. Usually a church is located there, along with a few other buildings, but except on market days the place is nearly deserted. As the country develops industrially, such accepted places for the exchange of commodities may develop into urban centers.

The Geographic Factor Within Cities

Many problems develop as a result of city growth, but only those of some geographic importance will be discussed.

Functional Zones in Cities. Cities vary in street pattern and in other characteristics. Very few cities have been planned in advance of construction (Fig. 259). Washington, D.C.; Canberra, Australia; downtown Indianapolis; and parts of Paris are examples of capitals built on a plan. A few industrial towns like Longview, Washington, and Gary, Indiana, were planned before they were settled, but most factory towns just "grew" and if planned at all were built for utility and economy

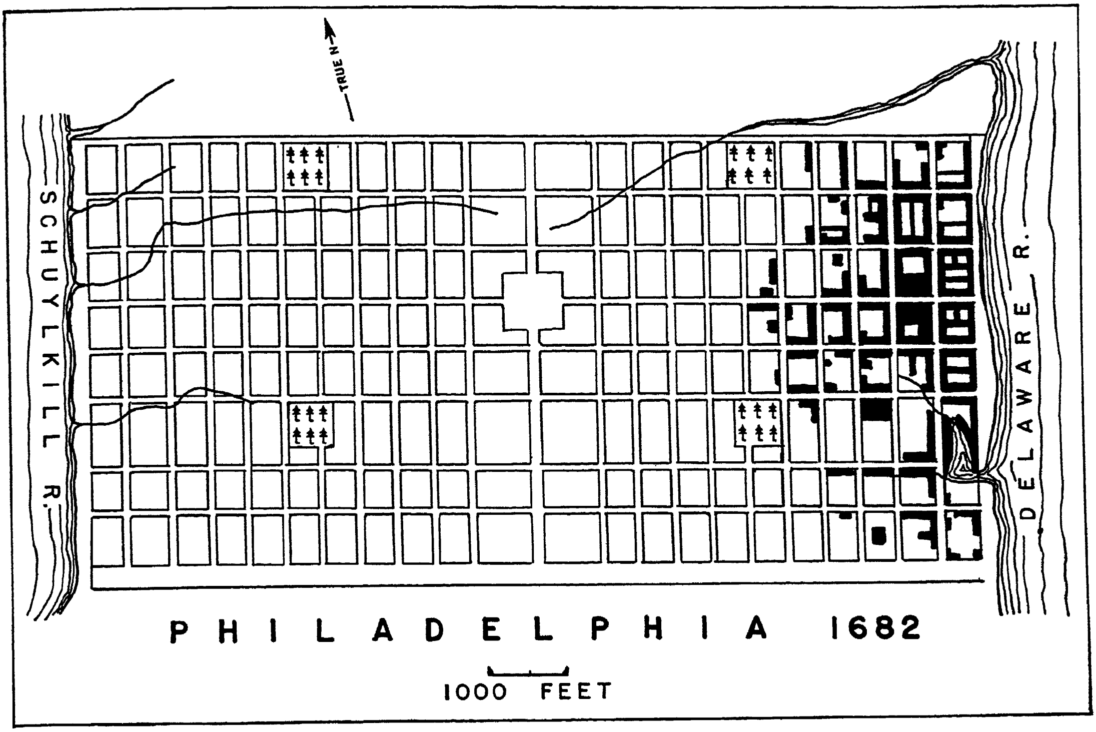

FIG. 259. William Penn's plan for the city of Philadelphia. One of the earliest examples of city planning on the grid, or lattice, pattern transferred to North American settlements. The center of the city was occupied by an open space, where the present city hall stands. Four other open areas, to be used as parks, were located symmetrically. Note that this plan takes account of the natural conformation of the site at only one place, in the southeastern corner of the city. Shaded areas indicate the actual settled urban community of Philadelphia in 1776.

rather than appearance. In general, however, every city has certain sections devoted to various uses, including the business center for offices, banks, theaters, hotels, restaurants, and retail shops; a commercial zone for jobbing and the wholesale trade; manufacturing or industrial areas, usually located along the rail lines for obvious reasons; residential sections of various sorts; a civic center, and park system; and outlying retail centers that serve the residents who live too far from the main business center to trade there.

Usually these zones will merge into each other by imperceptible degrees, although sometimes the line of demarcation is rather sharp. Around the old downtown district, there is usually a transition zone where former mansions are deteriorating and changing to business uses. In the meantime, the older houses may be used for cheap apartments and neighborhood stores until the ultimate most desirable use has been determined. Formerly apartment houses were located convenient to streetcars, subways, or interurban steam lines; but the development of the automobile permitted apartments and residences to become more independent of transportation methods that are restricted to definite routes.

Certain inventions led to the concentration of population in cities. The railroad and the electric car, especially when located in subways or on elevated lines, brought large numbers of people quickly into a limited area. To accommodate them, great skyscrapers were built until thousands of people could find work in stores and business buildings in a single block. With the coming of the automobile, downtown travel, which was already

congested, reached an impossible stage. Parking space was not available for all those who wished to work downtown or to shop or enjoy themselves there. As a result of the congestion, householders began to patronize neighborhood stores, until every large city in the United States today has numbers of these outlying centers on the main highways leading out of town at the intersections of principal cross streets and other desirable places. They represent a considerable degree of urban decentralization. The automobile permitted people to live in the suburbs or on hilly land where more light and air and view could be enjoyed away from the noise and dirt of the streets on which the streetcars and busses ran.

Since 1920, downtown districts of most American cities have actually lost population, and great growth has occurred in suburban districts. Thus first modern inventions encouraged the concentration of population in certain areas until the conditions there became unpleasant and a deterrent to business. Then a move outward from the city center developed which is still in progress. It should be emphasized that the true importance of a city cannot be told from the population included within its city limits but is indicated rather by the relative size, population, and importance of its metropolitan area—including the suburbs that closely adjoin a city and whose inhabitants are generally employed within it. Sometimes even the factors for which a city is noted are located in a suburb because cheaper building sites are available and taxes are lower. Thus Highland Park and Hamtramck, suburbs of Detroit, actually make many of the automobiles credited to the city itself. Even in a city like San Francisco, which is devoted more to commerce than to manufacturing, about half the population of the metropolitan area resides on the east side of the bay in Oakland, Berkeley, Alameda, and Richmond; or north of the Golden Gate and down the peninsula beyond the city limits. In New York, more than 1 million people reside on the New Jersey shore yet form a part of the business and residential area of metropolitan New York.

Changing Conditions in Cities. A principal factor affecting the location of manufacturing plants in cities of the United States, when establishments consume or produce bulky commodities, is the presence of large areas of cheap land favorably located for transportation, usually by rail or water. Such locations are usually on the outskirts of cities along the lines of the railroads and often utilize swampland or other cheap building sites that can be reclaimed. Near the factories spring up apartment houses and blocks of residences for working people who desire to live near their jobs. Some factories requiring much human labor rather than expensive sites for their success, like the manufacture of ready-made clothing, locate by preference near the heart of a city where labor can be secured easily.

The location of different uses for land in cities is not stationary (Fig. 260). Before the days of the automobile, a location near a railroad station was desirable. Now this is oftentimes an undesirable part of town, and the best retail shopping district is on broad streets away from the noise and smoke of steam engines, where parking space is available and access by automobile is easier. Zoning ordinances have helped protect residential neighborhoods; but when it becomes obvious that residence property can return better income if its classification is changed, this is done in most communities.

The fact that in cities many employees desire to live near their work leads to undue crowding and bad health conditions on the part of the people with small incomes. Those who enjoy larger incomes may live in the suburbs or in outlying residential neighborhoods with abundant space under healthy conditions, but the poor man is often crowded into tenements and slums that breed sickness and loss of efficiency. Both adults and children may lack facilities for proper recreation and tend to patronize undesirable places of amusement. Lacking opportunity for healthy

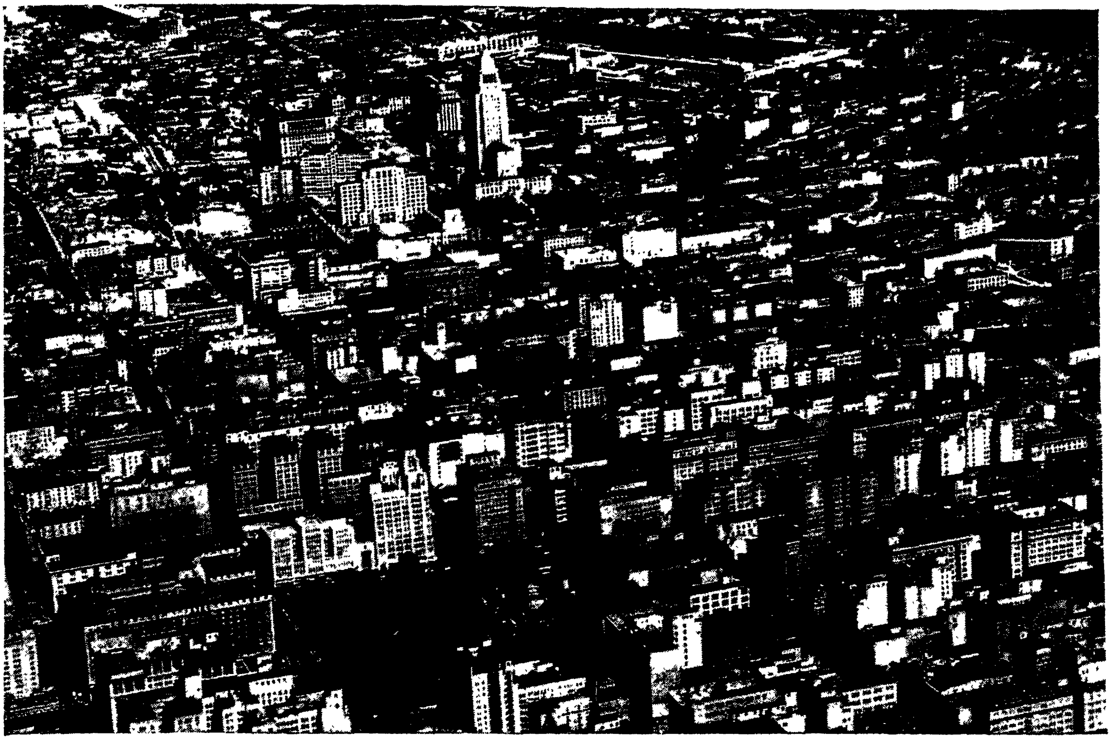

FIG. 260. Commercial core of the city of Los Angeles. Note the general uniformity in building height (except for the city hall and other municipal and Federal buildings in middle distance) as the result of earthquake threat. Rail yards are at the top of the photograph. Streets in the foreground are planned on a grid pattern of American origin; those in the upper right follow the lines of irrigation ditches and the streets of the original pueblo as planned by Mexican founders. Note the inadequacy of the park in the foreground in relation to the built-up area. (*Photograph courtesy of the Los Angeles County Chamber of Commerce.*)

play, youths sometimes join gangs that become trainers of criminals.

The birth rate among many city dwellers is lower than in the country. Although recent immigrants into industrial cities in the East may have average or above average sizes of families, the majority of married urban residents do not have enough children to replace themselves. As a result, cities grow at the expense of the rural population, because the actual and fancied better opportunities for advancement in cities cause people from the country and the small town to migrate to the city. Were it not for this continuous immigration from the rural to the urban centers, most cities of the world would steadily decline in population.

Special Social Problems of Cities. Many cities accommodate large groups of recent immigrants and residents who have been brought up under undesirable conditions. Through both ignorance and lack of desire for anything better, such groups of people oftentimes lend support to politicians and even racketeers or gangsters, with resulting bad influence upon the entire city life. Public improvements may cost more than they should, employees may be too numerous, and other forms of inefficiency and graft will result in high cost and poor and corrupt city government. Except during occasional reform moves, the majority of city dwellers too often become apathetic to the conditions, making it difficult to rouse their interest in an economical and efficient administration.

Although cities have social and economic faults, their advantages must outweigh their handicaps or they would not continue to

grow. Cities provide facilities for education, culture, and amusement not usually present in small towns. Superior medical attention and other services are available. A greater variety of opportunity in earning a living exists, and the general standard of existence is higher than in the country. City governments have generally tried to improve conditions by statute, including zoning ordinances; strict water, milk, and fresh-food inspection; ordinances controlling smoke and other nuisances; the building of parks; and improvements of housing conditions. A deep ravine, a wide river, a swamp, a hill, or some other obstruction often hinders growth of a city and expensive public works may be required to overcome it.

Many cities have planning commissions that endeavor to provide for the best orderly development possible, giving due consideration to the present layout of the city and the faults inherent in its site. Some cities have inherited narrow crooked streets from early days when building was done without any concerted plan. These in modern times become as much of a problem as any natural handicap.

The Patterns of Cities. The plans of most towns and cities when viewed from the air present a series of distinctive patterns. Some of those best known are the single-street, or "string town," type; the spider-web plan; the unpatterned plan; and the latticework, or grid, plan. These patterns may evolve in response to historical factors; for example, certain European towns and cities still show plainly their origins as settlements dating from the time of feudalism. The locations of former city walls, built for defense purposes, are marked today by the presence of broad boulevards, as in Paris. Typical patterns of Spanish and New England towns are centered around a plaza, as in Mexico City, or around the common land of the townspeople, as in New Haven or Boston. The most popular and widely used city pattern in the United States is the grid plan (Fig. 259), and it has been a distinguishing feature of our largest cities, including lower Manhattan, Philadelphia, Kansas City, Los Angeles, San Francisco, and Seattle. The pattern or plan of a given city may or may not be suited to the geography of the site. A grid pattern is entirely adapted to the relief of the land in Kansas City, situated on a plain, but the same pattern as it has been used on the hills of San Francisco or Seattle is wholly unsuited to the terrain.

Suburban Zones. Zones around cities are dependent for their support upon the city itself. Outside the populated and industrial area, part of which may be outside the city limits in adjacent suburbs, is a zone of markets, gardens, and greenhouses. Usually somewhat farther removed is the zone that supplies fresh milk, potatoes, and some of the needed vegetables and fruits. Beyond this is the general farming area for grain, hay, and livestock, which depends only in part upon the nearby city market. Scattered along the highways radiating from the city are fruit and vegetable stands, filling stations, eating houses, golf courses, and other places of entertainment and amusement. Around a growing city, the land devoted to gardens and farms may be taken over for real-estate development; here suburban houses replace crops, just as the business section expands and replaces residential areas near the city center.

Problems

1. Give several examples of "ghost towns" that have declined as the result of mine exhaustion.
2. Select one of the following commercial cities, and analyze its advantages and disadvantages as a trading center, with special reference to its most important exports and imports: New Orleans, Liverpool, Boston, Baltimore, Galveston, Vancouver, Portland, Oregon; Sydney, Calcutta, Yokohama, Bombay, Hamburg, Paris.
3. Name a city that is noted for each of the following: a resort; a city important for mining; a city having a favorable climate; a city handicapped by an unfavorable climate; a political city; a military city; a city that commands the entrance to a pass; a city that serves as a transportation center; a port city; a river port; a

canal city; a city that handles and mills wheat products; a city noted for fruit production; a city handling and processing cattle; a city on a coast plain; a city on an alluvial piedmont; a delta city; a plateau city; a city situated in tropical highlands; a city located on an ice-scoured glacial plain; a city whose trade is handicapped by a shallow harbor; a city handicapped by a frozen harbor; a city with a roadstead anchorage; a city having an artificial harbor; a city located on a fiord; a city on an estuary; a city at the head of ocean navigation on a river; a city important for power, a naval base.

4. What is the metropolitan area nearest your community? What type of goods do you buy there? Why?

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CHAPTER 25: *Geography and Nations*

In the preceding chapters of this volume, we have witnessed the close relationship among economics, agriculture, transportation, and other human activities, and the complexities of the natural environments that surround them. Political geography now comes to our attention, for governments and governmental institutions, no less than other elements of human culture, are affected by the geographical conditions that prevail in their particular environments. It is impossible to deal fully with the many aspects of the subject in these few pages, but some of the major problems can be suggested.

Boundaries

The most obvious aspect of political geography is the relation existing between political boundaries and their physical settings. At first glance this seems a simple matter, but no subject is more potentially (and at times actually) dangerous to the continued peace of the world. There are different types of boundaries, those which are relatively stable and those which may change within a generation or less. Some represent peaceful and fortunate relations between nations; others are breeders of suspicion, war, and distress. Some boundaries reflect the course of history, as the eastern boundary of Alaska represents the penetration of Russians in that direction on the North American continent. Others reflect cultural or language differences; still others represent military conquest. The boundaries within most of the continent of Africa stand for economic conquests of the closing years of the nineteenth century.

Some geographers take the view that political boundaries are not lines but are zones of transition separating major differences among people—differences of race, language, culture, ideology, and the like. A "racial" or, better, a cultural boundary is suggested by the line separating Burma and India, which have quite different cultures; and a "language" boundary is indicated by the French-Spanish border. These boundaries are seldom clear-cut, however, and often they are highly unstable. A "cultural" boundary follows the Rio Grande, yet there the zone of change is greatly blurred, with strong Mexican cultural elements lying north of the border in Arizona, New Mexico, and Texas. Rare indeed is the nation whose boundaries are well established and beyond challenge from its neighbors, and the United States is no exception to this statement.

Buffer States. Occasionally, in an effort to prevent military aggression by a nation, a "boundary state" or "buffer state" has been set up, separating two major powers. Buffer states are usually small in size, may have little or no justification from a geographer's point of view, and commonly lack those basic factors which tend toward the development of national consciousness. Afghanistan, between India and the U.S.S.R., is an example of a buffer state. At times, a small "boundary state" such as Luxembourg or Andorra is a relic state that has never been absorbed by its more powerful neighbors. As a rule the device of using a buffer state along a critical boundary has not succeeded for any length of time, and the practice seems outmoded by the speed with which modern warfare can attack.

Ocean Boundaries. One type of boundary, seemingly natural, is enjoyed by some few political units in the world. This boundary consists entirely of shores, and it has proved in the long run to be most satisfactory for defense purposes. In part, the mere fact of isolation by sea produces distinct political

entities—Australia, New Zealand, Great Britain, Madagascar, Newfoundland, and Cuba. Even such isolation as is enjoyed by Hawaii, Corsica, Sicily, or Jamaica lends those minor political units a character of their own even when they are dependencies of larger governments.

The character of the shore exerts a marked influence upon the development of a state. The ria coast of Dalmatia provides Yugoslavia with excellent anchorages, but access to the interior of the country is so difficult that the total effect is greatly lessened. Denmark's shore-line boundary is extensive, and there is no problem of reaching the interior, but unfortunately there are few first-class ports having adequate depth and shelter. Russia's ports are often icebound; Iran's seacoast lies distant from world trade routes; Peru's desert coast is approachable principally at roadsteads. These geographical facts are of great significance in evaluating the part any "marine" nation shall play in world affairs. At the same time, access to the sea is not an absolute essential to the existence of a nation, and isolation by land may provide a degree of political unity in nations like Switzerland, Bolivia, Austria, and Czechoslovakia. Nevertheless it is almost axiomatic that a strong political power must have adequate shores whereby its people can maintain contacts with the rest of the world.

Mountain Boundaries. In a few parts of the world, political boundaries follow mountain crests, as along the borders of Chile and Argentina or Norway and Sweden, but boundaries of this type are relatively rare. As a rule they tend to be stable; and, since they traverse no densely populated areas, seldom contain great mineral wealth, and can be defended with comparative ease, they are not often disturbed. Furthermore any differences that may arise over such boundaries are compromised more often than not. Chile and Argentina seem to have reconciled their claims; France and Spain have a joint working agreement for Andorra, and Italy and Switzerland have no serious boundary arguments. That is not to say that knotty problems do not exist, for the South Tirol question and several others remain unsettled after years of dispute. Certainly it should not be inferred that mountain boundaries are necessarily the most satisfactory type—contrariwise, they prevent easy mutual intercourse and understanding between nations by the very fact that the mountains act as barriers, as pointed out in another chapter. Furthermore mountain boundaries are difficult to patrol, and smuggling may develop extensively along these borders.

Boundary Difficulties. At the opposite end of the scale, many political boundaries traverse open plains or follow the courses of rivers, neither of which serves as a well-established or marked physical feature, for the river channel may change suddenly, and no landmarks of importance may be found on the plain. One of the most difficult river boundaries lies along the lower course of the Rio Grande, dividing the United States and Mexico. The meandering condition of the stream and the rapid deposition of silt in the river channel provide no satisfactory physical basis for the determination of the boundary. In the last two decades the channel has been straightened and the river's course shortened by cutting through the necks of meanders. Most of the cost of the operations has been borne by the United States, since this country profits most by the improvements. This type of boundary frequently is unstable and troublesome, for it may separate valuable mineral deposits, as along the Belgian-French and Polish-Silesian borders, or it may divide regions of dense population, as the border of the Netherlands separates its people from northwestern Germany. The problem becomes most acute when a boundary line divides a city, though this phenomenon rarely occurs in large urban centers along international boundaries.

In some places no boundary exists at present, but some type of boundary would normally be located there. The separation of the Walloons and Flemings in the heart of Bel-

gium, for example, suggests that this would be a logical place for a political boundary, yet none exists there. On the other hand, there are many examples of boundaries that in a sense are nearly inoperative except for the handling of customs duties, and along these boundaries there is little real need for the existence of a national boundary. An example of this "minimum" boundary lies between Canada and the United States. Most of the South American nations should enjoy this same type, with the possible exception of Brazil and the Guianas, which lie outside the Spanish-speaking realm of that continent.

Boundary Disputes. Many political boundaries in South America have sprung from historical rather than geographical or cultural sources. The presence, for example, of Brazil —a nation whose people speak Portuguese— is the outgrowth of accidents of geographical exploration and resulting papal edicts. Other political boundaries have less significant reasons for establishment, and many indeed are the arguments attending their location and settlement. Argentina and Bolivia are disputing possession of the Puna de Atacama; Argentina and Uruguay cannot agree on the ownership of a small island at the mouth of the Río Uruguay; Bolivia and Paraguay went to war over the Chaco; Chile struggled with Peru and Bolivia over the desert lands of Antofagasta, Tacna, and Arica provinces in the War of the Pacific in 1871; and Colombia and Peru disagree on the control of the Leticia district. If this list is formidable, it should be remembered that some 20 other South American boundary problems of major importance have been settled with some degree of satisfaction by means of arbitration.

European political boundary disputes are extremely involved and frequently are set forth as important causes of war. Among the significant problems are the insistence of Eire that she control northern Ireland (Ulster) and erase the boundary that now separates them. Italy tried to claim Corsica, Nice, and Dalmatia; Denmark would absorb Schleswig; and Bulgaria would like to annex the Upper Vardar Valley. These claims may not seem justified to many people; but German claims to Alsace and Lorraine, Yugoslavia's desire for Fiume, and Bulgaria's demand for western Thrace and southern Dobruja have been upheld by some because of language, history, or trade. Boundaries of Poland, Rumania, Finland, Czechoslovakia, Greece, and other European states have been in a highly fluid—almost volatile—condition for decades or centuries. In fact most of central Europe's "shatter belt" boundaries from Finland southward to Greece have been persistently unstable, partly because of differences in culture and language, and partly because of the misforfortunes of war.

It is increasingly apparent that international boundaries are beginning to lose their significance. The collapse of a Siegfried or Maginot line is evidence that they cannot be successfully defended by land forces. The entire concept of a national boundary as a fortress behind which a nation can retire and enjoy undisturbed seclusion from its immediate neighbors is undergoing a forcible change as modern military devices and methods, combined with the speed of aircraft, make boundaries ineffective military barriers.

The United States–Canada Boundary. The United States–Canada "unguarded" boundary is of special significance to this nation. The eastern portion between Maine and New Brunswick, and the western part between British Columbia and the "Oregon country" represent compromises brought about by lengthy negotiations. Disputes of some consequence raged at various times over those portions of the boundary along the St. Croix River, the Maine–New Brunswick land boundary, the Oregon boundary, the San Juan Islands, and the Alaska-Canada boundary. Many sections of the Canadian boundary run counter to the relief of the land; the Okanogan-Okanagan valley and highlands, the Columbia River Basin, Rocky Mountains, Red River Valley, the Great Plains, and Lake Champlain lowland are crossed nearly at right angles by the boundary. Major natural fea-

tures such as the Great Lakes, the upper St. Lawrence River, and the Juan de Fuca Strait are divided between the two nations, for the most part through the centers of the respective features. At first glance it would seem that this boundary must be extremely unsatisfactory, interfering with transportation routes, movements of people, and the flow of trade. In practice it has been eminently successful in its function, though not without some disturbances and recriminations on both sides. As time goes on, the boundary seems to lose its few barrier characteristics and functions; it has become a monument to the mutual understanding and common interests of the two nations.

Types of Boundaries. It is customary to speak of "natural" boundaries when special conditions of relief, such as mountain ranges, coincide with political boundaries, and this practice has been followed in this volume. In contrast, a geometrical boundary like that between the United States and Canada west of the Great Lakes is referred to as "artificial." There is no reason to assume that the latter type is more generally satisfactory or stable than the so-called "natural" boundary, for disputes between nations become acute regardless of the physical character of their political limits.

Natural boundaries are of many types other than those associated with mountains. They may occupy water divides between drainage basins, deserts, lakes, bays, navigable channels, straits, stream banks, tidal lines, canals, rivers (Fig. 261), valley bottoms, swamps, and other natural features of the landscape. The determination of those boundaries often causes trouble, for the feature must first be defined and then surveyed in accordance with the legal definition of the boundary. Sometimes it is almost impossible to obtain a satisfactory legal definition; for example, a boundary located in relation to the tides might be

Fig. 261. Gorge of the Columbia River, near Hood River, Oregon. This river marks the state boundary between Washington and Oregon. (Note the restricted space available for rail transport.) Rapids in this stream have been overcome by building canals around them, making the river navigable for some distance inland from the sea. This gorge is a transportation corridor of magnitude, and is partially ponded by the Bonneville Dam (Fig. 220).

defined as mean high tide, mean low tide, mean tide, the highest points reached by tidal action, and other interpretations of the phrase.

Geometrical boundaries may consist of straight lines that follow meridians or parallels of latitude, like the greater part of the United States–Canada boundary. They may follow curved lines, similar to the southeastern boundary of Pennsylvania, which is plotted on the arc of a circle. Even when these boundaries are defined legally, they are not always surveyed at once; for many years the southern boundary of Canada remained unsurveyed. This type of boundary, unfortunately, too often separates interdependent geographical units or violates geographical conditions in other ways. Not far south of San Diego, the United States–Mexican boundary along the straight line eastward to the Colorado River neatly separates San Diego from Lower California and parts of Sonora—territory that should normally contribute raw materials and commerce to the port but cannot do so as long as it lies within foreign territory (Fig. 262).

Boundary cities at the borders of countries often develop as twin cities on either side of the boundary along main routes of travel for convenience of the customs employees, importing, and travel, as at El Paso and Juárez, Detroit and Windsor, and Calexico and Mexicali.

Other boundary types include those based upon the limits of tribal movement, differences in language, differences in economic conditions, purely historical factors, different types of culture, and others. Most of the national boundaries of Hungary, for example, represent a combination of linguistic and cultural differences existing for a long period between the Magyar peoples within the nation and those of the Slavic nations that surround it.

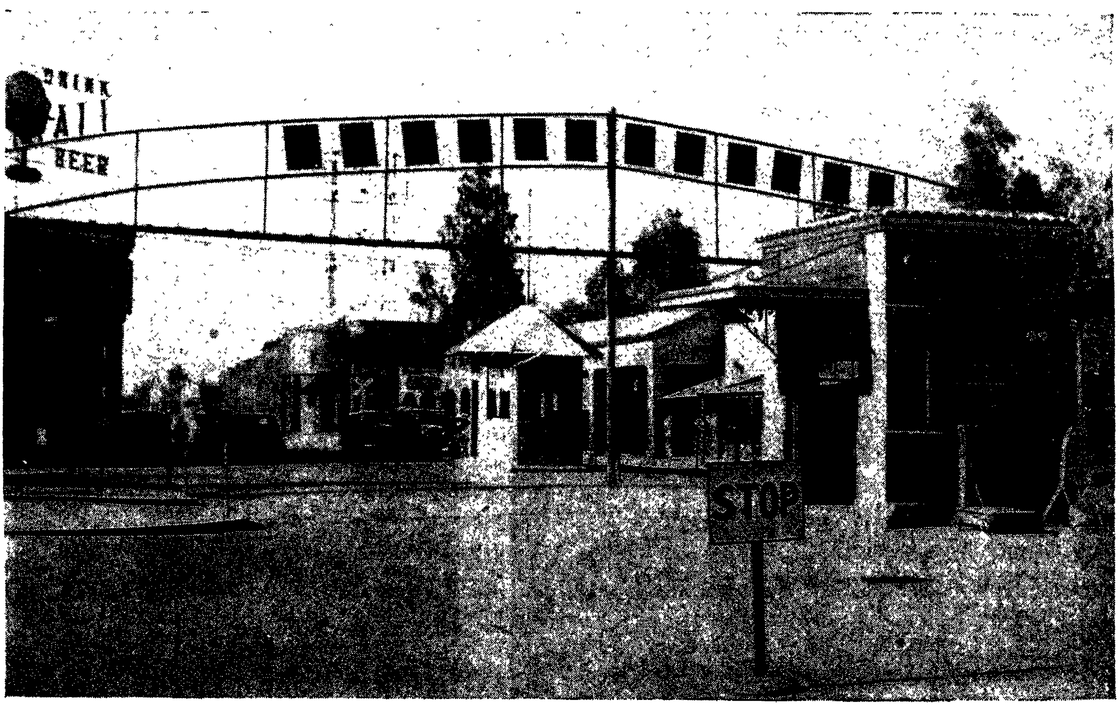

FIG. 262. The international boundary between Lower California and Mexico separates the towns of Mexicali, seen here on the other side of the gateway, and Calexico. Tourists and commercial vehicles are required to stop here for customs inspection and for other governmental procedures, but the boundary is not a serious problem for local residents who are known to the government officials stationed here.

Local Boundaries. Although it is the international boundaries that attract attention, from the standpoint of their total effect on human activity the local governmental boundaries are more important to individuals. The city, county, state, or province boundary largely determines whether city governments will provide conveniences or whether a given area will remain essentially rural in character. In this country local boundaries tend to follow geometrical patterns, particularly in the Middle West and the Far West; but in Japan, Norway, Switzerland, and other parts of the world there is a greater tendency to rely on natural features, property lines, or historical boundaries in determining the limits of secondary political units.

Boundaries are often not sufficiently flexible to permit change as population increases; thus the growth of urban centers can eclipse the original county in which they were located, as at San Francisco and New York. In these instances the county boundaries have become meaningless, and city and county governments have been merged. Both primary and secondary boundaries should be planned in such manner that they will be adaptable to changes in the geography, population, sociology, and economics of a given region. Otherwise they tend to become restrictive features of the cultural environment and thus become subject to dispute.

State boundaries in this nation have been the cause of numerous disputes, which have been carried to the Supreme Court from time to time. Texas and Oklahoma have had difficulty determining their boundary along the Red River. Pennsylvania and Maryland have had a boundary dispute; Louisiana and Mississippi have disagreed over De Soto Island near Vicksburg (Fig. 160); Wisconsin and Michigan have brought a boundary case to court; and North Carolina's southern boundary has been challenged.

Factors of National Strength

The Core of a Nation. For most nations, boundaries represent zones of political change, as already noted; but the heart of a nation as a rule lies in an interior location except for political units like New Zealand that have water boundaries, where peripheral geography is more important than any internal area. The true France, for example, may be said to center around Paris and Lyon rather than in Bordeaux, Marseille, or Nantes. German strength lay in Dresden, Berlin, and Munich rather than in Hamburg or Stettin. These "core areas" are the important centers of nations, and it is there that they are more nearly impregnable, because the core area is relatively secure from disturbances that may affect national borders.

The geographic character of a core area is of the utmost importance to the state that occupies it. If it is too arid, too humid, too cold, or too warm, that is, if weather conditions are unfavorable for most human activity, the chances of the rise of a dominant nation are relatively slight. It is difficult to create a nation of great military and economic strength if its heart resembles, for example, central Australia. Such a political structure would find itself hampered by inadequate supplies of raw materials. Geographic environment may be highly unfavorable to the advance of nations. Furthermore it may be unfavorable with reference to supplies of raw materials but favorable on every other count—good harbors, extent of cultivable land, and the like. Argentina's physical environment favors agriculture, grazing, some forestry, and other economies, yet her supplies of coal, iron, and other minerals are inadequate for the support of a nation of prime importance.

The size of the core area is a factor of consequence in the development of nations. Size alone may be a disadvantage, leading to difficulties of transport and communication and hence to disunity among the people. At one time—from 1850 to 1869 when the completion of the overland railway partly solved the prob-

lem—the United States occupied a core area that was ungainly and of such extent that the nation was almost torn apart by strong sectional feeling. We still recognize sectional influences, but we no longer regard them as serious threats to our national unity. Our common language was a great help in keeping the United States together.

The U.S.S.R. The Soviet Union, of course, is the outstanding present-day example of an oversize nation whose core area is almost too large to remain united. It will be interesting to note whether the Russian efforts to bring together the diverse views, languages, and peoples will be successful during the rest of this century. The problem is greatly lessened by such inventions as the telegraph, railroad, airplane, and radio. Russia's core area, with a wealth of minerals, electrical power, labor supply, and other resources, is by no means ideal from a geographic point of view, for there are some physical disadvantages that are serious. She has a very lengthy coast line, but most of it is arctic in character, and its harbors are useless most of the year. The harbors facing the Pacific Ocean also are troubled with ice and are far distant from the heart of the nation. Harbors on the Baltic are icebound each year and are located long distances from the open sea. Black Sea ports also face the latter problem. Siberian rivers are almost useless for transport, icebound each year, and flowing into an icy arctic sea. One of Russia's largest rivers, the Volga, is important for internal transport but useless otherwise because it enters an enclosed lake, the Caspian.

Some Geographic Handicaps. Not only is size sometimes a political disadvantage, but occasionally the internal geography is unsuited to the needs of a nation. In the United States, the Mississippi River would be of much more importance if it flowed in the direction of our principal routes, toward either Europe or Asia. As it is, it will never reach the peak of its usefulness unless the Caribbean becomes as important commercially as the Mediterranean. On the other hand, mere presence of an excellent waterway open to the sea—the Amazon, for example—is no guarantee that the nation which enjoys its use will be greatly enriched thereby if other geographical conditions are unfavorable.

Natural Defenses of Nations. If, in addition to a well-established unity of culture, a dense population and a good supply of natural resources are combined in the core area, the political strength of a nation is greatly enhanced by seemingly passive geographical conditions. This combination of circumstances leads directly to "strong" states. Though the combination is uncommon, it accounts in large part for the political and economic stability of the United States; of recent years we are witnessing other nations only beginning to gain strength because of the essential wealth of their core areas. Cases in point include the Soviet Union, Brazil, and, probably to a greater degree in the future, China. By the same argument, a political unit that lacks the necessary combination of geographical factors in sufficient force will have difficulty in maintaining the integrity of its borders. Australia, Arabia, Finland, and Norway would seem, on this basis, to be deficient in those elements on which strong nationalist states are built.

Applying something of the same concept on a continental scale, the idea of a "heart land" rich in natural resources, serving as an inexhaustible store upon which a nation or group of nations may draw for support, has been proposed to account for the development of economically and militarily "strong nations." Thus far the idea has not been put into practical use, for it implies a withdrawal from world affairs and a sharp decline in trade and cultural relations with other nations—in other words, a retreat to a core area, increasing self-dependence, and comparative isolation. In the modern world such a policy directed toward isolation would eventually bring national suicide.

One important aspect of a central rich core area is that it provides a refuge for cultural and military retreat when a nation's bound-

aries are violated by neighboring states. A military retreat to such an area takes the form of a negative defense—"defense in depth"—in which constant retreat draws an enemy toward the core until the problems of logistics are so great that the enemy forces are materially weakened and their defeat is an eventual accomplishment. The bitter defense of Stalingrad marked the climax of such a "defense in depth" on the part of its Russian defenders. Somewhat similar developments occurred when the seat of the Chinese government was moved to Chungking, effectively if not entirely removing it from the threat of capture by Japanese forces.

Natural Wealth of Nations. To a large extent the strength or weakness of political organizations, including national governments, is related to the amount and kind of natural resources that they own or control. It is not feasible, however, to regard the ownership of any single resource as guarantee of a strong state, for in the constantly changing modern world the emphasis shifts rapidly from one commodity to another. There was a time when plenty of good timber, supplies of naval stores, and skilled labor were adequate material to build a defense force. In more recent times armor plate, munitions, fuel oil, and medical supplies were essentials of warfare. In the future supplies of rare minerals such as uranium and extremely advanced technological processes may contribute more to the success of military operations than any other national resources.

Before our participation in war in 1941, a survey of "strategic" raw materials indicated that a successful American war depended in large part on supplies of antimony, nickel, tin, chromium, quartz crystal, manganese, quinine, Manila hemp, rubber, and silk. Of lesser importance, mica, quicksilver, tungsten, aluminum, coconut shell char, optical glass, and wool were nevertheless considered essential. Within a short time the list changed materially as reasonably successful substitutes were found for quinine, rubber, coconut shell char, silk, and wool, and undreamed-of supplies of some of the strategic minerals were located and developed in widely separated parts of the world. For other nations, the list of strategic materials inevitably varies, but the main point is apparent—those nations competent to acquire or produce sufficient raw materials are those which can wage war most effectively.

In the above list of strategic items, eleven of the seventeen were of mineral origin, four were of vegetable origin, and two were of animal origin. The importance of a rich supply of minerals cannot be overemphasized, not only those listed, but also iron ore, coal, petroleum, copper, lead, nitrates, sulphur, zinc, potash, and phosphate. These, with human ingenuity and the ability to work, are the foundations of a strong military, economic, and political organization today. To use them effectively, supplies of labor and electrical power, and some vegetable products such as cotton, rubber, and wool must be available in sufficient quantity.

In supplies of minerals, the United States is particularly strong in iron ore, coal, petroleum, copper, lead, sulphur, zinc, phosphates, and mica. Her most conspicuous deficiencies include manganese, nickel, chromite, tungsten, antimony, tin, and mercury. Some of these are available near at hand but not in great quantity or quality. England's position is strong in iron and coal; France has iron ore and aluminum sources. Germany is rich in synthetic nitrates, coal, and potash; Soviet Russia is developing a wealth of minerals, some of which have been hitherto unexploited, including coal, iron, petroleum, sulphur, manganese, chromite, potash, phosphates, mercury, and mica. Japan has supplies of coal, copper, and sulphur. Other major powers are not well endowed with mineral wealth but must obtain it from the smaller nations—iron from France or Sweden, nitrates and copper from Chile, sulphur from Italy, tin from Malaya, zinc and lead from Mexico, aluminum ore (bauxite) from Guiana, manganese from the Soviet Union or other sources, chromite from Turkey, nickel

from Canada, tungsten and antimony from China, and petroleum from Venezuela.

Efforts toward Economic and Political Self-sufficiency. Though mineral resources are basic in modern economies, they are not enough to establish strong states. The Soviet Union and China, both well endowed by nature with a wealth of minerals, have been extremely backward in economic and political advances; the former is only beginning to use her raw materials with effectiveness. Both have large reservoirs of labor supply—but whether the type of labor available can be geared to modern needs is a question that the future alone can answer.

Control of raw materials should lead to strength in time of peace, hence the scramble for colonial possessions and the sorry attempts to create empires based primarily on conquest. Almost the entire political map of the continent of Africa bears witness to the late nineteenth-century realization of the desirability of control of raw materials, including supplies of cheap labor. It is entirely feasible, of course, for a nation that lacks most of the essential raw materials to maintain a stable economy without the possession of a colonial empire, as Denmark has successfully shown for a century; but it is almost impossible for that nation to have a strong military organization. Political integrity can be maintained for centuries, even if both raw materials and internal unity of culture are lacking, as Switzerland effectively demonstrates.

Deficiency of essential raw materials may be overcome to a certain extent by exploration and development; the wealth of the city of Venice was based on this in the fifteenth century. At later dates, particularly during the seventeenth, eighteenth, and nineteenth centuries, the world witnessed the great expansion of the British people and the development of Britain's colonial empire, with its "Highway of Empire" to India and the Orient by way of the Mediterranean. Britain possessed coal in quantity, a labor supply, and the human wit to invent machinery to turn out large amounts of goods at small cost. Other raw materials of industry were noticeably lacking, but Britain's island location had forced her people into a seafaring life; ships and shipping they knew well. The ingenious combination of labor, fuel, and transport led to the creation of "a vaster empire than has been." In the case of England, certainly, a strong military power was created in spite of what would be regarded today as an almost hopeless deficiency of raw materials.

Shortages of essential raw materials may lead to military aggression if the people can be convinced that their national existence depends upon the acquisition of more sources of economic products—hence more land. This was the "have-not" argument that the military leaders of Germany used on two occasions to persuade their subjects to undertake wars of aggression. More recently, Japan embarked upon similar expansion and aggressive war on the continent of Asia and in Pacific waters. Many other considerations, including certain warlike human tendencies (Julius Caesar recorded the military tendencies of the Germans centuries ago), are responsible for aggressive wars; but certainly inadequate space for living as well as raw-material deficiencies are highly important in any list of the causes of war.

On the other hand, deficiency of raw materials and adequate supplies of food may lead to the weakening of a nation through emigration; this occurred in Ireland during the early years of the eighteenth century and again in the nineteenth century, when famine struck the land and many families were forced to leave for America and other parts of the world. Other migrations of a major importance have stemmed from similar causes in east central Asia. In general, however, it is becoming more difficult to advance nationally through the medium of exploration, conquest, or migration; we have reached a condition in which the nations quarrel over seemingly worthless land such as that in Antarctica.

Distribution of Land. One of the important political and social problems related to relief of the land and distribution of resources is

the size of landholdings. Under circumstances that allow the concentration of large landholdings and wealth in the hands of a few people, the political structure tends to become strongly undemocratic. Where the actual extent of cultivable land is limited, as in Japan, India, or even Hawaii, a feudal state is almost inevitable if too much wealth is held by too few. On the other hand, with wide fertile lands available for distribution to many people, as in Canada, the Soviet Union, and the United States, there is a marked tendency toward a democratic state. Some nations have attempted to correct maldistribution of land and to change economic life and political structure by law, as in Denmark, Poland, and Mexico. Sometimes this can be arranged peacefully; occasionally it leads to bitter internal wars.

Geographic Features as Nuclei for States. Conflict of national interest may occur over the control of a water or a land area. The large numbers of people whose activities are sea-centered include the Italians, Spaniards, French, Yugoslavs, Greeks, Turks, Syrians, Egyptians, and other North African peoples—of diverse interests, abilities, languages, and races. Yet they acquire a certain geographical unity that may transcend their national organizations, since the geography of the Mediterranean serves them all. Similar conditions around the Caribbean Sea, the Sea of Japan, and other landlocked water bodies have created geographical "spheres of influence" of some magnitude. A river-centered group occupies the Danube Basin—Germans, Austrians, Czechs, Slovaks, Ruthenians, Hungarians, Yugoslavs, Bulgarians, and Rumanians, and a multitude of minority peoples. Another river-centered group surrounds the Rhine, including the Swiss, French, Alsatians, Germans, Dutch, and Belgians. In these cases the common interest in the river is less unifying in its effect than is that of the inland seas.

Importance of Geographical Location. Geography frequently decides whether a given region shall capitalize on its natural resources or remain stagnant. The extremely remote location of Chile, Alaska, or the Union of South Africa makes it difficult for those governments to utilize their natural wealth, because of distances to consuming markets, lack of adequate labor supply, or other reasons. In some cases, as in the Belgian Congo, the type of native life partly accounts for an inadequate use of the natural resources. This may lead to immigration on a major scale; certainly this was one of the important conditions accounting for the displacement of the American Indian by peoples of European origin.

A large number of places on the earth, by reason of their peculiar geographical location, assume political importance out of all proportion to their character. These special sites include certain mountain passes, straits, corridors (longer and wider than passes), channels, and the like. Some, like the mountain passes already discussed—Khyber Pass, Brenner Pass, or the defile at Marathon—are famous, and their history is long and varied. Others are less important in political history but loom large in directing the course of events. The importance of Biskra's gateway to the Sahara, the Jade Gate near the western end of the Chinese Wall, the Cumberland Gap, or the Mohawk or Susquehanna corridors have all attained special geographical significance. To them should be added strategic straits, such as Malacca, Gibraltar, and Dover, which in reality are water passes.

Other important strategic locations may involve peninsulas, like Florida, guarding the Strait of Florida; Korea; or Calabria. Occasionally an isthmus location becomes highly significant, as at Suez or Panama; but passes, straits, and the like vary in their importance according to the course of world events; each may be extremely useful for a brief time and then lose its significant position. Once the Cumberland Gap and Magellan Strait commanded important routes, the first into the rich lands of Kentucky and the Ohio Basin, and the other from the Atlantic into the fabulous South Sea, or Pacific; today they are relatively unused, for the Cumberland Gap

has been replaced by more useful routes, and the construction of the Panama Canal made a trip around South America unnecessary for most shipping. It is difficult indeed to predict which particular location may assume importance in future; who can guess where another Bataan Peninsula will provide the rallying point for military action?

One highly strategic European location is controlled by a second- or third-rate power—Austria, with its capital at Vienna. The Danube, flowing eastward from Bavaria, traverses a narrow lowland between the Bohemian Forest, the Alpine ranges, and the Carpathians. Northward there is easy access to the plains of Bohemia, the Moravian Gate, Upper Silesia, and the Baltic. Southeastward the Danube enters the Hungarian plains, then the Iron Gate, and eventually the Black Sea. Southward the mountain routes of Styria lead over Alpine passes into Yugoslavia, Italy, and the Adriatic. At this commanding site, a weak Austrian state is in a position to control much of the European rail and river traffic and to stand, if necessary, as a fortress to prevent land movements of troops. Today Austria is a buffer, taking the brunt of attack by any power that moves eastward toward the Danubian basin or westward toward the plains of southern Germany.

Geography's importance in political matters has been satisfactorily stated by the editors of *Time:* "A nation's well-being under any economic system is limited by two things: the nature of the land and what is under the land, and the number and ingenuity of the population. A nation of clever and ambitious people with scant natural resources has but one recourse: it must sell its services by fabricating and transporting raw materials supplied by others." [1]

[1] Quoted by courtesy of *Time,* copyright by Time, Inc., 1948.

Problems

1. Select a boundary that is an example of one of the following types, and discuss its efficiency as a boundary: mountain, river, ocean, arbitrary.
2. Do mountain crests usually make good national boundaries? Defend your answer with specific illustrations.
3. On a map of the United States, revise the state boundaries to conform more closely to the geographical boundaries.
4. Discuss the following quotation from a geographical standpoint: "It may be feasible to plan a city division or possibly even a small city but no one knows enough to plan wisely for a state."
5. What part of the Canadian-American international boundary do you consider most satisfactory? Why? Which part is least satisfactory? Why?
6. To what extent is the possession of unexploited mineral resources a liability to a nation whose military defenses are weak?
7. What difficulties may be encountered along state boundaries which are defined by law as the center of river channels?
8. What difficulties may be encountered along international boundaries designed to follow the center of river channels?
9. On a map of the world, indicate in red those international boundaries which are currently in dispute.

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CHAPTER 26: *A Survey of the Continents*

The seven continents are divided, as a rule, into those of the Old World—Asia, Europe, and Africa; and those of the New World—North America and South America, with isolated Australia and uninhabited Antarctica the only ones lying wholly within the Southern Hemisphere. Most of the land area of the world lies in the Northern Hemisphere, as indicated in Table 7; hence we commonly refer to the Southern Hemisphere as the "water hemisphere."

TABLE 7. AREA OF THE CONTINENTS

Continent	*Millions of square miles to nearest thousand*
Africa	11,710,000
Asia	17,000,000
Europe	3,750,000
North America	8,665,000
South America	6,938,000
Australia	2,975,000
Antarctica	5,250,000 (estimated)

The World Island or Old World

The Old World, or world island of some geographers, consists of three closely contiguous continents—Europe, Asia, and Africa. From a physiographic standpoint, Europe is essentially a peninsula of Asia or of the continent and might better be called Eurasia. Only a portion of the Ural Mountains is now used as a Europe-Asia boundary, and the Caucasus Range is included with Europe along with the Trans-Caucasus region south of the mountains. The delimitations of the Europe-Asia boundary are based more on cultural, racial, and historical grounds than on natural earth features. The boundary between Europe and Africa is all water, and that between Asia and Africa is mostly along the water. The Sinai Peninsula is a part of Egypt, an African country; hence the Africa-Asia boundary line runs from the Gulf of Aqaba to the Mediterranean and not across the Isthmus of Suez, which is the narrowest land connection between the continents.

Europe is wholly outside the tropics, and most of the continent is in the northern mid-latitudes. Climatically Asia is wholly north of the equator, but it extends over so many degrees of latitude that most types of climate—from wet equatorial to the polar tundras—are found on the continent. The principal exception is the west-coast marine climate which occurs in Europe but not in Asia. Africa is crossed by the equator at about the middle distance from the northern and southern limits of the continent; thus Africa essentially is a tropical and subtropical land mass. Until less than a century ago interior tropical Africa was unknown to Europeans; for the extensive desert toward the north, swamps on the upper Nile, rapids on other rivers, and swampy forested coasts backed by steep cliffs combined to discourage exploration and penetration for trade and settlement.

Each of the three continents has a core or "shield" of ancient rock, to which more recent geologic formations have been added. The highest mountain ranges are geologically young, trend generally east and west, and are located between the areas of hard old rock, which probably were the resistant blocks of the earth's surface between which weaker rocks were folded and heaved up to form the mountain systems like the Pyrenees, Atlas, Alps, Carpathians, Caucasus, Hindu Kush, Altai, Himalayas, and other ranges. In Europe the chief remnant of very old land is in Scandinavia. Asia has two centers of hard ancient rocks; one in Siberia and the other in India.

The area of old rocks in Africa makes up most of that continent south of the Sahara.

Europe. Europe's area is approximately 3,750,000 square miles—only a little larger than the United States including Alaska—yet in this territory live over half a billion people. Europe, exclusive of the U.S.S.R., has 400 million people in an area of about 2 million square miles. From these figures, it is apparent that Europe offers great advantages as a home for man.

Europe's Favorable Geography. Environmental factors prevailing in Europe, including the climates, relief features, shore lines, and natural resources, are generally favorable for man. Climatic conditions are stimulating, and in most areas there is adequate rainfall and favorable temperature for plant growth. Only a small part of the continent north of the Caspian Sea is too dry, and the arctic shore line and higher mountains are too cold for crops. The mountains trend generally east-west, protecting the Mediterranean shores from excessive winter cold and permitting mild moist air from the Atlantic to moderate the climate of west central Europe.

Europe has many plains; and, though some are of small extent, they support large numbers of people. The hills and mountains are smaller in area than the plains, and many of the upland regions are not so rugged that they cannot support surprising numbers of people. There are many navigable rivers, and the generally low elevation of the land favors canal construction. The extensive plains are an aid to land transportation because construction of railroads and highways is easier and cheaper than would be possible were Europe a more mountainous continent. Relief features often vary widely within limited areas.

Ocean transportation is generally easier around Europe's shores and in her harbors than on any other continent. Good harbors are fairly numerous as the natural result of a highly irregular shore line, which is marked by ports at the mouths of numerous navigable rivers. The continent is deeply penetrated by seas—the North Sea, Baltic, Mediterranean, Black Sea, and the Adriatic—and these provide ocean ports located within a few hundred miles of any part of western and southern Europe. The interior of no other continent has the degree of accessibility that Europe enjoys in its ocean transport and its coasts and harbors.

The natural resources of Europe are many, though they are not always adequate for the needs of her people. Coal, petroleum, and water power provide energy, and agriculture is highly productive on large areas of fertile soil. Forests are important in some parts of the continent and contribute their wealth to human activities. Iron ore is abundant, and many other metals and nonmetallic minerals occur in good supply. Local differences in relief features, soils, and various other resources result in much differentiation and variety of industry; this in turn encourages exchange of products between the adjoining areas of the continent.

Physical Regions. The three great physical relief regions in Europe are (1) the northwestern highlands; (2) the central plain, and (3) southern Europe. The last named consists principally of peninsula, mountains, and small basins.

Northwestern Highlands. The foundation of the continent consists of old crystalline rock, which outcrops chiefly in the northern highlands across Ireland, Scotland, Scandinavia, and Finland. In this northern portion the highlands are hilly uplands and rolling plateaus cut by deep valleys rather than high mountains, except for parts of the Norway coast. In Finland and adjacent areas, erosion has reduced the once-high mountains to a gently rolling plain. All the northern area has been strongly glaciated, with the result that lakes abound, though much of the scoured bedrock lacks good soil on its surface. Tillable land is limited to the valleys, and the soil is often poor. This, combined with a short growing season, limits crops to hay, roots, and hardy grains. Forest products, grazing, dairying, and fishing are typical industries. The

meager population is concentrated in the lowlands. The coasts are much indented with deep fiords, of which those of Norway are most noteworthy. In Norway and other rugged areas much water power is available, and some chemical and other manufactures are based on cheap hydroelectricity. Building stone occurs widely, and there are some metals, of which the iron of Sweden is best known. Stockholm, Oslo, and Helsinki are combined seaports and capital cities and are the largest population centers in their respective countries. Bergen, Norway, and Göteborg, Sweden, are other seaports. No large cities are located in interior regions.

The Central Plain. The central lowland, or great European plain, leads the continent in agriculture, manufactures, commerce, and population. The region extends from southern Ireland and England over western France, Denmark, northern Germany, Poland, and most of Russia from the Black Sea to the arctic. Most of the rocks that outcrop on these plains are of sedimentary origin, and coal beds are common in some parts. Sometimes the surface is broken by the occurrence of small hill areas of older rock and, toward the north, of glacial moraines and other deposits. Many lakes and abandoned glacial spillways that once carried the melt water from the ice front are indicators of the extent of continental glaciation.

The climate of the plain is dominated by frequent cyclonic storms, which bring rainfall and changeable weather, and by its exposure to the winds from the Atlantic Ocean whose moderating effects extend far inland because no high mountain ranges stand across the path of the westerlies. Winters are long, cold, and snowy in Russia but become progressively less severe westward. The central plains are the most favored parts of Europe for most human activity. They grow the bulk of the wheat and other grains, sugar beets, potatoes, and flax and support the majority of the livestock on the continent. Toward the north, where coniferous forests are dominant, soils tend to be infertile, but in most areas where the natural vegetation consisted of hardwood trees and grass the soils are rich and productive. The black soil of the level grasslands in Rumania and the Ukraine is ideal for growing wheat.

These plains are drained by navigable rivers—the Thames, Rhine, Elbe, Oder, Vistula, Dnieper, Volga, and many others. The building of canals, railroads, and highways is easy, and manufacturing is based largely on supplies of local iron ore, coal, and other materials as well as on important products.

Nearly three-fourths of the entire population of the continent dwells on the plain. Most of the large cities of Europe, including many main seaports, are located on the plain. A railroad map indicates that in most European countries many lines diverge like the spokes of a wheel from the capitals and some other centers. London, Paris, Berlin, Warsaw, and Moscow are major focuses for rail routes. Other inland centers, particularly devoted to industry, include Birmingham, Essen, Cologne, Leipzig, Dresden, Frankfurt, Kiev, and Kharkov. Many of the leading seaports of northern Europe are near the mouths of rivers whose valleys provide natural routes to the hinterland. Liverpool, London, Bristol, and Newcastle are English cities of this type. In France, Bordeaux, Nantes, and Le Havre are ports near river mouths. Antwerp in Belgium; Hamburg, Bremen, Emden, and Lübeck in Germany; Riga and Leningrad in the U.S.S.R.; and Danzig in Poland are among other ports of the central plains. Odessa in the Soviet Union, and Constanța, Rumania, are leading ports on the Black Sea. From these and other ports are sent the manufactured goods from the continent; and in return minerals, food, raw materials, and luxuries are imported from abroad.

Southern Europe. The third great physical region, southern Europe, consists of three major peninsulas—the Iberian (Spain and Portugal), Italian, and Balkan—together with young folded mountains north of the Mediterranean Sea forming a nearly continuous series of ridges from Cape Finisterre to the

Dardanelles and associated basins, valleys, and small plains. The peninsulas differ in their geographical features. Iberia is predominantly a plateau; Italy is made up of the Apennine Mountains with their associated hills and lowlands; and the Balkans are principally rugged mountain country which in Greece has been partly submerged by the sea, leaving a coast made up of islands and hilly peninsulas.

The shores of the Mediterranean, with few exceptions, as in Yugoslavia, enjoy the mild Mediterranean climate. Inland the climatic conditions change to the continental type, with summer rains in place of the Mediterranean winter rainfall; winters of the interior tend to be much colder than those of the southern shores.

Mountains and hills, along with several important basins and valleys, occupy the country between the Mediterranean Sea and the central plain. Eastward from the Alps are two major mountainous arcs. The northern extends through Austria and then continues in the giant curves of the Carpathian Mountains and Transylvania Alps to the Danube River at the Iron Gate and into Bulgaria. The ridges of the other arc border the Adriatic Sea on the north in the Julian Alps and on the east in the Dinaric Alps, continuing southeastward into Greece as the Pindus Mountains. In Yugoslavia these ridges parallel the Adriatic and hinder penetration of the interior because few passes lead to the coast.

The mountains bordering the central European plain on the south are older than the rugged ridges near the Mediterranean Sea. As a result, the mountains in southern Germany and central and northern France have rounded slopes and typically support extensive forests. Among these mountains most of the people live in basins and valleys. The largest basins include those of Bavaria, in which is situated the important city of Munich; the basin of Bohemia, in which Prague is located; and that of Hungary, in which Budapest is the metropolis. The Danube River gives access to these three basins and other fertile areas. In all, the Danube affords a navigable waterway to seven nations and is a principal transportation corridor between central and southeastern Europe.

As a consequence of the enclosure of the Mediterranean Sea by highlands along its northern border, the principal breaks through the mountain barriers determine the routes penetrating central Europe, some of which cross the continent to the North and the Baltic seas. One of these routes follows the valleys of the Rhone and Saône rivers through the pass at Belfort to the Rhine Valley and thence to the North Sea. From the head of the Adriatic Sea, a route leads north across the Danube River through the pass called the Moravian Gate to the Oder River and the Baltic Sea. In the mountainous Balkan Peninsula the most accessible and historic route extends from Salonika on the Aegean Sea up the Vardar River Valley over a divide to the Morava and down this stream to the Danube near Belgrade. From Nish in Yugoslavia a branch extends eastward by way of Sofia, Bulgaria, to Istanbul on the straits between the Aegean and Black seas. Armies, immigrants, pilgrims, and traders have marched and countermarched along these historic routes. Today railroads and improved highways utilize them. To reach the Po Valley in northern Italy the longest tunnels in the world, the Simplon (12⅓ miles) and the St. Gotthard (9¼ miles), were constructed through the Swiss Alps, whose height precluded railroad building over them. Although the Alps are a great barrier to transportation, they benefit many by the abundant water power that has been developed and by keeping from Italy the worst cold blasts of winter from off the Russian steppes.

The plains of southern Europe are small as a rule, that of the Po Valley being largest in size. They are densely settled, and living standards for many of the farmers tend to be lower than those of northwestern Europe. In those parts having a Mediterranean climate, vineyards and orchards are important in the landscape, and fruit, olive oil, and wine

are shipped to the colder regions of western and northern Europe. Grazing of sheep, goats, and cattle is common, but there is little timber for human use except in the mountains of the Balkans. Coal, oil, and metals are scarce, and manufacturing is less important here than in the more favored plains of central Europe. Many of the cities, however, have numerous factories in operation, particularly in Milan, Turin, Marseille, and Barcelona. Madrid is located on a semiarid plateau, but typically the larger southern European cities are either commercial ports or are built near the sea; this is the case at Lisbon, Valencia, Barcelona, Genoa, Rome, Naples, Athens, and Istanbul.

Geographic Importance of Europe. For several centuries Europe has carried on more foreign trade than any other continent. This comes chiefly from (1) the large population, which has a relatively high standard of living compared with that of most of the people who live on other continents; (2) the importance of manufactures, which can be exported and for which quantities of raw materials must be imported; (3) the lack of certain minerals, especially petroleum; (4) the necessity in many nations for importing foodstuffs for man and feed for animals; (5) imports from regions of different climate like the tropical countries; and (6) the fact that much of the traffic, including specialized manufacturing, is foreign in Europe because of the small size of many nations, whereas in a large country with varied industries such trade would be domestic.

Europe has expanded its trade by different methods. The continent has led not only in most lines of manufacturing but in the building and operation of ocean shipping to transport goods all over the world. Banking and foreign investments of Europe were important aids for the development of trade. Western civilization or culture, which stems from Europe, has spread around the world, and its impacts can be perceived even in remote parts of the earth. European languages, religion, and culture have overrun the Americas, Australia and New Zealand, South Africa, and many islands and parts of Asia, and they have had profound effects in every nation of the world.

European powers have political control over most of Africa, some of southern Asia, some parts of the Americas, and many of the world's islands. Recently there has been a strong tendency toward decline in the political domination of colonies by European countries. Some of the colonies, such as Hindustan, Pakistan, and Burma, have become independent; others like Ceylon have become self-governing dominions.

Asia. Asia is the largest of the continents and supports over half of the world's people. This continent has wide variations in climate, relief features, and ability to support life. Some parts of Asia enjoy very favorable soil and climate conditions, leading to intensive agriculture; other portions are very unfavorable and as a result are very thinly populated.

Geographical handicaps that tend to retard Asiatic peoples include (1) a pronounced lack of first-class harbors; (2) the difficulty of penetrating the interior of the continent because of the great distances and the lack of many favorable routes leading to the interior; (3) the desert climate experienced by a large part of Asia and the climate that makes much of the far north too cold for human use; and (4) the vast extent of the high plateaus, mountains, and deserts, which repel travel and transport to the interior. The natural consequences of these geographical conditions are that many parts of interior Asia are so isolated from the rest of the world that the people who live there have tended to stagnate in their cultures.

Climate. There are many different climatic types in Asia, but the principal factors affecting the climate are: (1) The continental location in the stormy westerly wind zone of mid-latitudes in northern Asia. Southward from the Arctic Ocean in the interior are broad belts of tundra and taiga, steppes and desert lands, as described in an earlier chapter. The tundra and taiga continue eastward to the Pacific, but deciduous forest is found in southeastern Siberia, northern China, Korea, and

Japan. (2) Monsoon Asia includes the southern half of the east coast, the Malay Peninsula, and India. (3) Southwestern Asia from the Indus Valley to the Red Sea is desert. (4) A fringe along the Mediterranean Sea is Mediterranean in climatic character. (5) The elevated interior has cold climates resulting largely from the altitude. The land utilization of Asia is closely related to these climatic regions.

Highlands. Asia is built around a mountain core, with high plateaus centering in Tibet and the Pamirs. All the way from Turkey to China there is a double series of mountain ranges. From the Pamir knot of high plateaus and mountains, the Altai, Altyn Tagh, and Kunlun rise to the north and east, the Karakorum and Himalayas to the south, and the Hindu Kush and Sulaiman lie to the southwest of the "roof of the world." Southeast from the Himalaya Mountains several ranges trend into China, Indo-China, the Malay Peninsula, and the Netherlands Indies. Westward the Hindu Kush and Elburz mountains guard the plateau of Afghanistan and Iran (Persia) on the north, and mountain ranges continue westward into Turkey to the south of the Black Sea. In south and southwestern Asia are three peninsular plateaus, Anatolia (Asia Minor), Arabia, and the Deccan of India. Besides the mountains and Tibetan plateau in central Asia, there are lowland basins, of which the Tarim and Dzungarian in China and the depression of the Caspian and Aral seas are most important.

Plains. Asia's fertile plains support most of the population in the east and south portions of the continent, but some extensive plains are unsuited climatically for cultivation because of low temperatures in the north and drought in the interior. The latter type of plain may be made useful if supplies of water for irrigation can be obtained. River and coastal plains are the most densely populated types. The rivers of Asia drain to the north, east, and south from the Tibetan highlands. Most of the people and activities of southern and eastern Asia are concentrated in river valleys, the larger of which include the Tigris-Euphrates, Indus, Ganges, Brahmaputra, Irrawaddy, Menam, Mekong, Si (West), Yangtze, Hwang (Yellow), and Amur. Deltas and coastal plains in India and China support millions of people, as do the Manchurian lowland and the interior basin of Szechwan in China. Offshore islands like Japan, Java, Sumatra, and the Philippines also are well developed and extensively used by man. Rice is the favored food crop in the monsoon tropical and subtropical climates, but cotton, jute, tea, and vegetable oils are also important products. Silk is manufactured, especially in Japan and China.

In the cooler and drier regions, wheat, millet, and grain sorghum are favorite food crops. Soybeans are important in Manchuria. Much of Siberia is a vast lowland sloping toward the arctic and drained by the Ob, Yenisei, and Lena rivers; but, because of the cold climate, the population in these river basins is relatively sparse. Along the arctic are the little used tundra lands, then to the south the broad taiga belt of spruce, fir, and pine. Next toward European Russia is a zone of fertile grasslands in which most of the Siberian production of wheat is cultivated; this area in turn grades into the steppes and deserts of central Asia. Summers are hot in Russian Turkestan, east of the Caspian Sea, and there is little agriculture except in the oases where cotton, alfalfa, and some food crops for local use are raised by means of irrigation.

Natural Resources. The natural resources of Asia have been very unevenly developed. The soil is used intensively in the monsoon lands and is the principal support of man in this continent. Vast forests in Siberia are still little exploited. Potential water power is very great, but only Japan has developed important amounts of hydroelectric power for her own use. The mineral resources have been tapped to some extent but are capable of much more expansion. Petroleum and coal production in particular seem to offer wide possibilities for the future. Tin, iron, gold, and other metals are being mined, but much

of Asia has not been prospected extensively, and hence it is probable that many occurrences of metals remain to be discovered.

Transportation. In development of transportation, Asia has made some progress but still remains behind both Europe and North America because the natural features and the human management are not so favorable as on those two continents. In all of Asia only one railroad, the Trans-Siberian, crosses the length of the continent, and over vast areas there are not even adequate highways. Only in Japan and India have railroads been built in reasonable adequacy to meet the needs of those countries.

The largest seaports in Asia generally are located where they have easy access to a major valley or productive plain. Good harbors are not common along much of the Asiatic coast, and some of the great ports like Shanghai have developed where the harbor is poor but where the location is convenient to a highly productive hinterland. Sometimes, where an irregular coast has many harbors, as in southeastern Asia, the port cities are relatively small because access to the interior is prevented by mountain ranges near the coast.

Asiatic Nations and Their Trade. In prewar years Japan carried on most of the foreign trade in Asia. Japan is a small nation in relation to its large population; most of the people live in cities and on scattered little areas of fertile farm land. Both light and heavy industry were well developed, considering the slender resources available in the home islands. Tokyo is the largest city and principal port; others of importance include Yokohama, Osaka, Kobe, Nagasaki, and Nagoya. Raw silk, tea, cotton textiles, rayon, and a host of small articles were prewar exports; cotton, petroleum, metals, and foodstuffs were imported.

India is so isolated from the rest of Asia and of such ample size that it is almost a subcontinent. The Himalaya Mountains enclose the peninsula on the north; their southern slopes descend to the fertile alluvial plains of the Indus and Ganges rivers; these in turn give way to the Deccan plateau in the extreme south. India is now an independent nation, along with the Moslem-peopled Pakistan, which includes northwestern India and the province of Bengal. Nearby Burma is also independent, and Ceylon has been granted dominion status by Great Britain. Most parts of India are reached by railroads radiating from the important ports of Bombay, Calcutta, and Madras. Karachi, capital of Pakistan, and Colombo in Ceylon are two other leading seaports of this area. Exports of jute, cotton, vegetable oils, spices, and minerals are important. The Ganges Valley is particularly well developed for agriculture and commerce; numerous railroads and the river itself serve Delhi, Cawnpore, Benares, Lucknow, and other cities.

In Burma, Siam (Thailand), Indo-China, and the Malay Peninsula transportation is by means of rivers, coastal steamer, short railroad lines, and increasingly by highway and airway. The seaports, like Singapore and Georgetown on Penang Island, and the interior center of Kuala Lumpur handle much of the rubber, tin, and other exports of Malaya. Bangkok in Siam and Saigon, Hué, and Hanoï in Indo-China are important ports and trade centers for shipping rice, rubber, and other tropical products. In the Netherlands Indies, Batavia on Java, Makassar on Celebes, Palembang on Sumatra, and Bandjermasin on Borneo are locally important seaports.

China is the most populous country in the world, but most of its people are subsistence farmers, and they carry on relatively little manufacturing and trade though they have been skilled artisans for many centuries. One of the great needs of the nation is improved transportation. Rivers, especially the Yangtze, carry much freight and are supplemented by thousands of miles of canals in the deltas and flood plains of the Yangtze, Yellow (Hwang), and West (Si) rivers. Short rail lines run inland from several coastal cities, but through lines are rare. All railroads experienced some damage during the war between China and Japan. The most important line

connects Canton, Hankow (inland on the Yangtze), and Peking (Peiping). Peking also has rail connections with Manchuria and its port, Tientsin. Shanghai on the delta of the Yangtze is the greatest port in China. Silk, tea, plant oils, and other products are sent out from it to world markets. Dairen is the principal port of the Manchurian region, with Mukden and Harbin leading inland cities.

In area, Siberia is the largest part of the U.S.S.R., but it is only partly developed. The Trans-Siberian Railroad, which terminates at Vladivostok, ties the country together and traverses the most fertile and populated strip of land. Chita, Irkutsk, Tomsk, Omsk, and Novosibirsk are among the important cities in the interior of Siberia. Great resources of land are suitable for wheat and mixed farming and for forests, fish, furs, and minerals; but most of these are still to be developed. Coal and iron ore have led to the construction of heavy industries in western Siberia.

Southwestern Asia is a land of plateaus, mountains, and plains, much of which has a desert or near-desert climate. Historically it is the site of ancient empires and civilizations, but in today's world it lacks essential resources, and its population is scant except in those areas where the climate favors human occupation and where water can be obtained for irrigation. Petroleum is the most valuable mineral produced in Iraq at the present time; and it also comes from Iran, Arabia, and Bahrein Island in the Persian Gulf. Palestine with its principal city, Jerusalem, is a center of interest for many pilgrims and tourists; to the Moslems, Mecca in Arabia is the great center for pilgrimages. The railroads are inadequate in number throughout this part of Asia; usually they are used as feeder lines to serve local seaports. A railroad (unfinished) is to extend across Turkey and Iraq from Istanbul to Bagdad and on to Basra on the Persian Gulf. The one railroad in Iran extends from Bandar Shapur on the Persian Gulf to the capital, Tehran.

Africa. The continent of Africa, from a historic and cultural standpoint, is divided into (1) a northern fringe always closely related to Asia and Europe in its races, politics, and culture and (2) the central and southern sections, populated largely by Negroes or negroid peoples; this section has long been isolated from contacts and trade with the rest of the world. The Sahara covers an area about the size of the United States and forms a barrier between the two cultural parts of Africa so broad and difficult to cross that only a few yearly caravans make the journey. Even today, though men can cross this desert barrier by means of the speedy airplane, it remains a major problem of transportation for ordinary trade and travel.

North Africa. Northwestern Africa is backed by the Atlas Mountains; along its coast lies a zone of Mediterranean climate. From here many products, including grain, wine, olive oil, hides, iron ore, and phosphate rock, are shipped from Algiers, Casablanca, Tunis, and other ports to France and other countries, chiefly in Europe.

In Egypt is found a marvel of irrigation in the desert Nile Valley. Most of Egypt's exports consist of cotton from the Nile delta sent through the port of Alexandria. Upstream from Cairo a combination of river boats and railroads around unnavigable stretches of the river provides service to Khartoum in the Anglo-Egyptian Sudan. A railroad also runs from Khartoum to Port Sudan on the Red Sea, from which cotton and other products are exported.

Central and South Africa. The two-thirds of the continent of Africa lying south of the Sahara consists of a plateau of hard ancient rock material rising abruptly from the ocean in most localities. The conditions in tropical Africa so discouraged exploration, settlement, and the opening of the interior to trade that it remained unexplored and undeveloped until late in the last century. It is difficult to land through the surf and hard to penetrate the forests from the shore. The edge of the plateau is marked by a succession of rapids and waterfalls in the rivers which prevents their use for navigation to reach the interior;

the edge of this plateau resembles a mountain barrier in its geographical effect.

Central Africa is so difficult of access that it was first entered by Europeans from South Africa, a long but more open route. On the north was the wide barrier of the Sahara and the very difficult swamps, called the *sudd,* along the upper Nile. Near the equator the Congo River drains an interior basin of the same name and is an outlet for palm oil and other tropical products, though the many rapids in its course are a distinct handicap to its use for transportation.

If a coastal lowland is found at all around the continent, it is usually narrow and is either desert or covered with pestilential mangrove swamps and jungles. There are very few good harbors.

The East African Plateau and that of Ethiopia and interior Eritrea have such high altitudes that they are reasonably healthy and invigorating, thereby encouraging some settlement by Europeans. The southern Belgian Congo and parts of Rhodesia are also favorable for white settlers because of their altitude. Mountain ranges are rare in Africa, and much of the interior plateau surface is open and easy to cross. East Africa lacks long chains of mountains, but isolated mountain peaks do rise to such altitudes that they are snowcapped almost on the equator. Examples include Kilimanjaro, Kenya, and Ruwenzori. A striking feature of this part of Africa is the presence of two rift valleys—narrow, elongated, and deep sunken trenches—crossing the plateau. The Great Rift Valley has several large lakes in its depths, including Tanganyika, Nyassa, Albert, and Rudolf. The largest lake, Victoria, is outside the Rift Valley. The highest peak in West Africa is Cameroons Mountain, which rises near the angle of the Gulf of Guinea.

South Africa. This section of the continent is a favored part both in climate and in natural resources. The pleasant Mediterranean zone lies near Capetown, and inland the high veld has sufficient elevation to make the climate healthy. Near Durban on the east coast the warmth and freedom from frost permit the growing of sugar cane and other subtropical crops. The principal exports from the lands of South Africa are wool, meats, and hides. The region is a great producer of gold at Johannesburg; diamonds at Kimberley, near Pretoria, and other places; and copper from upper Rhodesia.

Transportation Conditions. Africa's transportation problem has always been difficult to solve, and lack of easy access to the interior is so discouraging that those sections long remained unexplored. Now railroads are under construction, but most of those in tropical Africa are unconnected single lines running inland from the little port cities to tap the supplies of palm oil, peanuts, mahogany, and other exports. The southern part of the Belgian Congo has large copper mines in the Katanga district; the copper is exported, and the needs of the mines for machinery and other things have caused railroads to be built to this area from Lobito on the Atlantic coast of Angola, from Beira in Mozambique on the Indian Ocean, and from Capetown on the south, in addition to the slow route by way of the Congo River with its portage railroads. In addition to copper ore, there are some exports of cotton, hides, coffee, and sisal fiber. Abyssinia (Ethiopia) is located on such a high rugged plateau that it is difficult to enter this part of Africa to carry on trade. Only a single narrow-gauge railroad runs to the capital, Addis Ababa, from a port in French Somaliland.

Air routes are becoming of importance in Africa; and passengers, mail, and package freight now fly in a few hours distances that once took as many weeks or even months of weary travel by boat, animal transport, or trek on foot.

World Relations. Africa is important, geographically speaking, for its strategic location and for its numerous European colonies, which serve as rich sources of needed raw materials to feed the factories of Europe.

The most strategic location in Africa is the Suez Canal, and the political and military

control of this vital link for ocean shipping between Europe and southeastern Asia has been of major concern, especially during wartime. North Africa must also be controlled by any power that seeks to use the Mediterranean during wars, and highly strategic points are the constrictions at the Strait of Gibraltar and near the island of Malta. Only about 1,200 miles of sea separate Africa from South America; and, in this age of aviation, the control of the west African shores at Dakar and Freetown was important to safeguard the air lane from the Americas to the Near East during the war. Ascension Island in the South Atlantic Ocean was developed as a landing field on this route.

Africa was not defended strongly by the native peoples when its riches attracted the interest of Europeans; it was easy for the great powers to establish colonies here, and most of the continent today is ruled under the colonial system of government. Reasons that led to the establishment of the colonies include (1) the control of sources of raw materials for manufacture, (2) markets, (3) places for investment of funds, (4) a place for emigration and settlement, and (5) strategic purposes and imperial power and prestige. In general the colonies have not been successful and have represented a financial drain upon the governing power; only Tunis, Algeria, and South Africa have large numbers of settlers of European descent. Many parts of Africa provide severe climatic handicaps to European settlement, as well as the competition of cheap native labor.

Africa as a source of raw materials, foodstuffs, and minerals is of great importance to Europe, which also supplies most of Africa's imports. Cotton, vegetable oils, wool, hides, cacao, grain, and some minerals are among the African products shipped to European cities. Other materials include timber, fertilizers, metals, and ores. In general, Africa supplements European economy, and European nations desire the continued expansion of trade and development of African resources under their management.

The New World

The land area of the New World covers a scant half of that of the Old World, and its continents are more nearly separated from each other. Both North America and South America are roughly triangular in shape, and they possess young mountain chains close to the Pacific and older worn-down mountains near the Atlantic coast. A central lowland extends north and south between the two mountainous areas. Climatically, however, the similarities cease. North America is wholly north of the equator, the narrowest part of the continent lies within the tropics, and the land mass broadens in the mid-latitudes where stimulating cyclonic storms occur. Furthermore much of the land in the tropical zone consists of highlands, which help to counteract the handicaps of low-latitude location. In contrast, the greatest width of South America almost coincides with the equator, and much of that continent within the tropics consists of lowland, though extensive tropical highlands are beneficial for human use and health. Only the narrow triangular southern portion of South America lies in the cyclonic belt of the mid-latitudes. Trade-wind and "rain-shadow" deserts occur on both continents but are not so extensive as are those of Asia, Africa, or Australia. Northern Canada, Greenland, and much of Alaska are far too cold for crops or tree growth. There the population is very sparse, and little trade may be expected to develop in future. Only the southern tip of South America and the higher mountains and plateaus have a similar climate.

North America. North America has several advantages over some of the other continents when it comes to use of the land. That part within the United States includes a major portion of the part of the continent most favored for farming, mining, and other occupations. Unfortunately in North America the

widest part of the continent, near the arctic, is also the least habitable part. The continent was favored for settlement by Europeans because of the presence of large plains with adequate rainfall and fertile soil; climates similar to those of Europe, favoring the transfer of familiar systems of farming and crops and livestock to the New World; great resources of timber, coal, iron, and other minerals; the presence of water power; a plentiful supply of fish and game; an irregular coast; and inland waterways and broad plains leading to the interior.

Descriptions of the climatic conditions have been given in Chaps. 8, 9, and 10 and will not be repeated here. The relations of forest types to climatic conditions are included in Chap. 11, and the agriculture is described in Chap. 18.

The Relief of the Land. The Canadian, or Laurentian, shield is the principal area of ancient rock material in North America; it includes most of New England, eastern Canada, Newfoundland, Labrador, the Lake Superior region, and the Adirondacks in New York State. Beyond this large, roughly triangular area most of the other major relief features of the continent are aligned approximately in a north-south direction. From east to west in the United States these include the Atlantic coastal plain; Piedmont Plateau; Appalachian Mountains; Appalachian Plateaus; interior lowlands; the Great Plains; Rocky Mountains; intermontane plateaus and basins; Sierra-Cascade Mountains; the great valleys of California, Oregon, and Washington; and the Pacific coast ranges. Beginning with the interior lowland, these features continue northward into Canada. The interior lowland on the south grades into the Gulf coastal plain, which is also a continuation of the Atlantic coastal plain. South of the Mexican boundary the principal features include a central upland or plateau with associated mountain ranges and numerous volcanoes; the coasts are fringed with narrow coastal plains along much of their distance.

The Canadian Shield and the Eastern Highlands. The easternmost portion of North America is made up of resistant ancient rocks extending inland from the "stern and rock-bound coast" of New England, Nova Scotia, Newfoundland, and Labrador. A large part of Canada from the St. Lawrence and Great Lakes to Keewatin, west of Hudson Bay, is a peneplain consisting of the eroded bases of ancient mountains. This area is named after its shape, the Canadian shield with the higher portion near the river being called the Laurentian upland. The New England upland, Canadian shield, Adirondacks, and Lake Superior region experience a severe climate; the forests are principally coniferous, and some parts are well endowed with minerals, including deposits of gold, silver, copper, iron, and asbestos. Because of glaciation and the general resistance of the rock, these areas are covered with numerous lakes and enjoy a wealth of water power.

The Adirondack Mountains represent an outlier of resistant rock. Another area of old crystalline rock material extends southwest from a point near the Hudson River into Georgia, and forms the Piedmont Plateau.

The Appalachian Mountains and Plateaus are composed of sedimentary rocks and are much younger geologically than the Piedmont or the Laurentian upland. The ridges and valleys of the Appalachian Mountains are west of the Piedmont and trend in a southwest-northeast direction, continuing all the way from northern Alabama to Newfoundland. Still farther inland is the deeply eroded Appalachian Plateau, divided into the Allegheny Plateau in the north and the Cumberland in the south. Folded rocks related to those of the Appalachians occur in northern Arkansas. The Ozarks make up an outlier of older rocks rising above the interior lowlands.

The Plains. Beginning at Cape Cod and Long Island is the Atlantic coastal plain, which merges with the Gulf coastal plain in the South. The Atlantic and Gulf coastal plains are widest toward the south and include the whole of Florida and up the Missis-

sippi Valley as far inland as Cairo, Illinois. The Gulf Plain continues down the coast of Mexico and middle America and includes the whole of the Yucatán Peninsula.

The interior lowlands occupy the upper Mississippi Valley and extend northward as far as the Arctic Ocean. The lowlands rise to the westward; the elevated semiarid grasslands between the 100th meridian and the Rockies are called the Great Plains, and these extend well north into Canada. The whole Canadian area and the northern lowlands and Great Plains in the United States have been glaciated with considerable effect, particularly in the formation of lakes, in the creation of water-power sites, and in the different possibilities for land use. The vast plains between the Appalachians or the Canadian shield and the Rockies are the "bread basket" of both the United States and Canada. In this country the Cotton Belt is included in the southern part. Occurrences of petroleum, coal, and building materials, along with iron, copper, lead, and zinc, are available near at hand and have contributed to the importance of manufacturing. These lowlands constitute the heart of both the United States and Canada.

Western Uplands and Lowlands. The Rocky Mountains extend from a point near Santa Fe northward and northwest through Canada and into Alaska. The Rockies are important sources of minerals, timber, and water power, as well as water for irrigation. They are a considerable barrier to transportation, with the result that railroads and highways tend to be concentrated in the principal valleys and through the lower and most convenient mountain passes.

Between the Rockies and the Sierras and Cascades are plateaus and intermontane basins. The Columbia intermontane province of plateaus, hills, mountains, and basins drained by the Columbia River is the northern one of these in the United States; the Fraser Plateau in British Columbia occupies a corresponding position on the other side of the boundary. The arid central portion between the Rockies and the Sierras has the Great Basin, or basin and range province; in southern Utah and adjacent parts of Colorado, Arizona, and New Mexico is the high Colorado Plateau, which is deeply trenched by canyons.

West of the intermontane regions are the Cascade and Sierra Nevada ranges, then two broad lowlands, the Puget-Willamette trough and the Great Valley of California, separated by the Klamath Mountains. These valleys are followed by the Coast Ranges along the Pacific. Northward, Vancouver Island is an extension of the Coast Ranges, the lowland has been submerged, and the Pacific coast range of Canada becomes practically the continuation of the Cascades. Southward a coast range forms the peninsula of Lower California, and most of the lowland east of this is submerged to form the Gulf of California.

The Alaska Range, the crest of North America, rises from the Gulf of Alaska without lowlands and is a pronounced barrier to transportation into interior Alaska. Further, it prevents the encroachment of marine air from the Pacific Ocean reaching into the northern part of the continent. This towering range extends as an east-west trending arc and continues through the Alaska Peninsula and the volcanic Aleutian Islands toward Asia. Interior Alaska is a broad and rolling plateau or plain drained by the Yukon and Kuskokwim rivers (Fig. 117). It is bounded on the north by the Brooks Range, or arctic highland, beyond which is the arctic plain, tundras sloping toward the Arctic Sea.

Mexico and Central America. Mexico is essentially a plateau bounded by mountains and narrow coastal plains on both sides. The surface of the interior plateau is interrupted by mountains, between which are basins often arid enough to lack drainage to the outside. East of the low Isthmus of Tehuantepec and south of the equally flat Peninsula of Yucatán are highlands that include several volcanoes; these mountains extend southward through Panama to South America. Popocatepetl (17,883 feet) and Orizaba (18,700 feet), both snow-capped, are among the volcanic peaks occurring in Mexico.

The concentration of population in Mexico occurs on the central plateau, and the people of Central America also live by preference in the highlands, which are healthier and cooler than the lowlands in these latitudes. Mexico City and most of the other capitals and larger tropical cities of North America are likewise located in the highlands. In Mexico, livestock and subsistence farming are principal occupations, though plantation production of sisal in Yucatán and of cotton in several parts of Mexico are important locally. The country is a leader in its mineral production, especially for copper, lead, zinc, and silver; it has some useful petroleum deposits. Coffee, grown in the highlands, and bananas in the lowlands are typical agricultural products of Central America.

More transportation facilities would be of great help in Mexico and in Central America. Mexico is moderately well supplied with rail lines and highways, both of which connect with the United States, but there is great need for extending both systems. Even more remains to be done in Central America, where the railroads are short lines carrying bananas and coffee to various small ports on the route to world markets, and where several large sections of the Pan-American highway are still unfinished.

The Panama Canal is of the greatest international and strategic importance. Before the canal was finished, the Tehuantepec railroad across the isthmus of that name had much significance, but it is now of little importance. The United States has arranged for rights to build a canal across Nicaragua and may in time exercise that privilege.

Excellent steamship and airplane service is available from the United States, especially the gulf ports, connecting with Central America, Mexico, and the Caribbean islands. Several air lanes also provide fast service in this part of the world.

Trade Centers of the United States and Canada. The United States carries on the most foreign trade of any North American country; and, in proportion to its population, Canada is of similar importance. Both countries have vast resources, extensive plains, and generally favorable climate in the populated portions, and they are favored by the ability of their people to develop and use these. The United States and southern Canada have natural routes, like the Great Lakes and St. Lawrence, which favor the transportation of commodities, but man has also helped nature by the construction of railroads. Many trade centers are primarily the result of railroad development.

The geography of the principal trade routes, land uses, and cities of the United States has been described in Chaps. 22 and 24.

South America. Triangular-shaped South America is situated southeast of North America and is somewhat smaller and less favored for settlement than the northern continent. The principal physical features are comparatively simple: (1) Closely parallel to the Pacific shore is the mountain system of the Andes, one of the greatest in the world. Folds from the northern Andes extend eastward to enclose the Caribbean Sea along its southern shore. (2) The Central Lowland extends the length of the continent and is drained by three main river systems, the Orinoco, Amazon, and Paraná, the last-named flowing into an estuary called the Río de la Plata. (3) The highlands of Brazil with their crest near the Atlantic seaboard. (4) The Guiana highlands in the northern part of the continent.

The Brazilian and Guiana highlands have in general much more ancient rocks than the Andes or the lowlands. That part of the lowlands in the rainy tropics is covered with dense forests, and it repels rather than attracts settlers. Some of the highlands that would favor human use as far as temperature is concerned are too dry, rough, or rocky for successful farming.

The mineral resources of South America are great. Many important metals are mined, including copper, tin, gold, silver, and tungsten. Petroleum is abundant, and there is much potential water power, but coal resources are of minor significance.

Manufacturing is of only local importance but is expanding somewhat in amount. The people of the continent as a rule are forced to import most of the manufactured goods they use.

The Andes and the West Coast. The Andes cordillera so closely adjoins the Pacific Ocean that the drainage is divided most unevenly, with the large river systems all tributary to the Atlantic. The Andes traverse the full length of the continent and are its most outstanding single feature; they are particularly important in considering the distribution of rainfall and the interference with travel. Associated high plateaus and mountain valleys in low latitudes are preferred by most Europeans and many natives as places of residence; they are usually much more comfortable than the hot rainy lowlands. Most of the republics in low latitudes have located their capitals and their principal cities at high elevations, sometimes exceeding 2 miles above sea level. Examples include Sucre, La Paz, Quito, Bogotá, and Caracas.

The coast of Peru and northern Chile, known as the Atacama Desert, has numerous oases, particularly in Peru. Here sugar cane and cotton are raised for export. In contrast, the rainy tropical lowlands of western Ecuador produce cacao, tagua nuts, and the fiber for manufacturing Panama hats. The Andes of Bolivia, Peru, and Chile have rich metal mines, and nitrates are still exported in some quantity from the Chilean desert.

In Chile, there is a coast range somewhat resembling the similar feature in North America, then a longitudinal valley above which rise the Andes Mountains. A general picture of Chile's climatic types includes desert in the north, Mediterranean in the central part, and rainy west-coast marine climate in the south. The central valley is most important and has the capital city of Santiago with its principal outlet at the port of Valparaiso. Wheat, wine, and livestock come from this central region. The northern desert region produces nitrates, iron ore, and copper; its ports mainly exist on mineral exports. Rail lines from Antofagasta and Arica extend into Bolivia and deliver the tin ore and other minerals of that nation to the ships that transport them to England and other countries. A longitudinal railway extends northward from Santiago into the desert, but it was built primarily for strategic reasons and carries little freight, since coastwise ships have lower charges.

The principal Peruvian port is Callao near Lima, the capital, and these cities are connected by rail. A second railroad also connects the inferior port of Mollendo with Lake Titicaca, where a small ship provides service across the lake and delivers goods to another rail line leading to La Paz in Bolivia. Cotton, sugar, wool, copper, and vanadium are sent out from Peru. Guayaquil, with its railroad to Quito, the capital, is the leading port of Ecuador.

The few railroads in Colombia and Venezuela, like those of Peru and Ecuador, are principally of local value. There is a complete lack of rail connections among the various capitals of the nations in northern and Andean South America; highways are often poor and sometimes entirely lacking. Mountains rise within sight of the ocean and present difficulties of construction for railway and highway engineers. As a result, air travel is encouraged and is widely used throughout the western parts of South America. The interior rain forests and grassy plains are thinly populated and as yet remain unreached by railways from the Pacific or the Caribbean. In Colombia the Magdalena River is a principal route, although its use by river boats is handicapped by rapids and great variation in flow. Petroleum and coffee are the main exports of both Venezuela and Colombia. Barranquilla on the lower Magdalena River has its ocean outlet at Puerto Colombia nearby.

The South American Lowlands. Climates of the central lowlands of South America are governed in their distribution by the latitude; natural vegetation and land use vary accordingly. Tropical rain forest covers the coast of the Guianas, most of the lowlands near the Amazon River, and the very narrow coastal

plain northward from Rio de Janeiro. North of the Amazon River Basin lie the llanos of the upper Orinoco region; southward are the open woods (campos) of the savanna region of southwestern Brazil and neighboring parts of Bolivia, Paraguay, and northern Argentina. The tropical grasslands are used to some extent for raising cattle, but the tropical rain forest has been developed very little, although some sugar and rice are produced in Surinam and British Guiana.

The well-watered plains, or pampas, of Argentina inland from Buenos Aires are devoted to raising wheat, corn, flax, alfalfa, and livestock. Westward and southward from the fertile pampas the rainfall decreases in amount, and the countryside is used for grazing except where irrigation has reclaimed some of the drier parts. The oasis at Mendoza is famous for its wine; others nearby produce sugar, rice, and cotton. Southern Argentina (Patagonia) is semiarid but colder than the northern part of the country; its precipitation is just enough to provide for forage, and it is used almost wholly for the extensive grazing of sheep.

The pampas of Argentina are well served by rail lines (Fig. 245), with tracks diverging inland from the principal ports of Buenos Aires, Rosario, and Bahía Blanca. One line, from Buenos Aires, connects in the north with Bolivian lines and thence with Pacific ports in Chile, but most of Argentina's railroads are of local importance and were built to carry wheat, corn, flax, quebracho extract, wool, and livestock to seaports for shipment to Europe and the United States.

Buenos Aires, the largest city in the Southern Hemisphere, is built upon a harbor that was originally shallow, but is now improved. This city is the capital, the leading port, the principal manufacturing center, and the greatest business city of a very fertile and productive nation.

Across the La Plata estuary, Montevideo, capital of Uruguay, is located on an excellent harbor from which several railroads diverge; these are used to transport cattle, sheep, and wool to the port, animal products being the chief export. Montevideo is the business center of this small but productive country, but it has a population only about one-fifth that of Buenos Aires because of its limited hinterland.

The Eastern Highlands. The eastern highlands of Brazil are the most productive parts of that country and support the largest part of the total population. The soil and climatic conditions are favorable for crops like coffee, cotton, and corn, and the altitude is high enough to make the region healthful and pleasant for its latitude.

The Brazilian highlands consist of old resistant rock, representing the eroded remnants of a former mountain massif. Their rounded hills offer sharp contrasts to the more youthful Andes chain, where narrow canyons and steep slopes dominate the mountain landscapes. Together with the Guiana highlands, they partly enclose the interior plains of South America. The eastern highlands rise steeply from the Atlantic and lie parallel to the coast; as a result, the steep mountain grades that are necessary to cross the heights make railroad construction to inland centers both difficult and costly. The Brazilian highlands contain valuable minerals, of which gold, manganese, and industrial diamonds are noteworthy. There are large resources of iron ore, which Brazil has begun to manufacture into steel at a new plant.

Santos is the port for the city of São Paulo, the largest interior city of Brazil, and it is the leading port for exports of coffee. The railroad connecting the two cities was exceedingly expensive to build. São Paulo is a wealthy city, not only important for coffee production but of increasing importance for industries like the manufacture of cotton textiles.

The largest city of Brazil is the capital, Rio de Janeiro, with over a million population. This is the leading seaport and business center of the country, and it enjoys the advantage of a particularly fine harbor, although access to the hinterland is somewhat hampered by

the heights behind the city. There are some rail connections leading to the interior, and one line traverses all of Brazil to the border of Bolivia.

Southern Brazil resembles part of the southern United States in its climatic conditions and its agricultural crops. Here pine lumber, cattle, swine, corn, and wheat are produced in quantity and are shipped from the leading ports of Porto Alegre and Rio Grande do Sul.

North of Rio de Janeiro, Bahia (São Salvador) and Pernambuco (Recife) are the principal urban centers and ports. They export large amounts of cane sugar, cotton, and cacao.

The Guiana highlands along the northern Brazilian boundary and in Dutch and British Guiana are seldom visited and are of negligible importance. They have some forest resources and some possible mineral deposits but are mostly undeveloped. Bauxite is mined near the coast of British and Dutch Guiana and is exported to the United States and Canada for the manufacture of aluminum.

South American Potentialities. South America has many resources, some of which have been developed only slightly. There is opportunity for larger population density in most parts of the continent (Fig. 250). Indeed the Amazon Valley is almost empty of people compared with the numbers it could support theoretically if the practical problems of life in the rainy tropics could be overcome. The pampas of Argentina, the llanos of Colombia and Venezuela, the interior territory of Mato Grosso in Brazil, and a few other parts of the continent are capable of providing for many more people than those who live there at present.

At present South America is significant for her exports of raw materials, particularly minerals and farm products. The United States imports wool and flaxseed from Argentina; coffee from Brazil and Colombia; oil from Venezuela and Colombia; cacao from Ecuador; tin from Bolivia; nitrates, copper, and iron ore from Chile; bauxite from the Guianas; and many other commodities in an unmanufactured condition. Most of Argentina's meat and wheat are sent to Europe, and that continent also buys mineral products and coffee. South America imports most of its manufactured goods, but in future her industry can be expected to increase. Only Chile has important coal deposits, but there is much petroleum and water power available, and in time South America will at least supply most of its requirements for ordinary manufactured products. South America presents an attractive field for investment and expansion of trade, to both Europeans and North Americans.

Australia. Australia is the smallest inhabited continent, and the geographical conditions affecting transportation and human activities in general there are simple compared with those in other populated continents. Only Antarctica, which has no permanent inhabitants and is dominated by intense cold, covered by glaciers on land, and surrounded by ice-covered seas, has more obvious geographic disadvantages than Australia.

The continent of Australia lies south of the equator, athwart the southeast trades. This results in desert conditions over the whole of the central and most of the western sections. A rim of adequate rainfall follows the northern, eastern, and southern coasts except for an arid strip along the Nullarbor coast of the Great Australian Bight between the favored southeast and southwest areas of the continent. Unfortunately for human use, northern Australia has a wet-and-dry tropical climate with an average of 6 months of drought; its soils are generally poor, its known resources are scant, and its population is almost negligible. Most of Australia's population of about 7 million is concentrated in the southeast where the two large cities, Sydney and Melbourne, are located, each having more than a million inhabitants. A well-peopled zone extends north into southeast Queensland, where Brisbane is the principal city. South Australia around Adelaide and part of southwest Australia are favored by a Mediterranean climate; these constitute other developed regions. A

fair number of people live in Tasmania, but scarcity of tillable land allows the population of that rugged island to increase but slowly.

Australia rests on a firm foundation of ancient crystalline rocks which outcrop over most of the western and much of the central parts of the continent. Once this region was mountainous, but through millions of centuries the rugged highlands were worn down to a nearly featureless peneplain with an altitude of only one to two thousand feet in elevation; above this a few ridges of resistant rock rise to greater heights. Most of this peneplain is a desert. Gold mines in western Australia have induced some settlement at Kalgoorlie, Coolgardie, Boulder, and other mineralized locations, but most of the enormous area is unpopulated and is unlikely ever to support any considerable numbers of inhabitants.

Australian Railways and Their Terminals. Human factors have materially influenced the location and gauge of Australian railways. At first there were five separate colonies (six with Tasmania). The continent has a rather regular coast line, and first-class harbors are uncommon. The provincial capitals were customarily founded on one of the few good harbors. The capital became the chief seaport and dominant trade center of each colony. When railways were built, they naturally radiated from that capital city. This helped to concentrate commercial, manufacturing, and governmental activities in the six state capitals and caused so much urban growth that more than half the population is living in the cities. An unfortunate circumstance prevailed, in that the different colonies, now the states of the Commonwealth, did not adopt the same railway gauge. Thus New South Wales has standard gauge, Victoria a broad gauge, and Queensland a narrow gauge. As the result, all freight, passengers, and mail must be transferred from one train to another at most state boundaries—in itself an expense and a nuisance, especially for transport between large cities like Melbourne and Sydney.

Much of Australia's freight is carried by coast ships, since the largest cities are seaports. Improved highways, including paved roads, have been built to connect the cities in settled parts of Australia, especially in the southeast; but bus service is not generally available because the railroads are owned by the government, and the authorities fear the railway income would suffer from competition with interstate busses. In the back country the roads are little improved, but the extensive open plains make travel by car and truck possible in most sections.

Trade and Commerce. Australia is most famous for its exports of animal products. The climate is mild, and stock require no shelter. Neither is feeding generally resorted to except during prolonged droughts; these are the greatest handicap to the grazing industry. Native grasses are excellent and recover quickly when rains follow a drought. Enemies of livestock are few, the principal one being a wild dog, the dingo, which kills some sheep, and the introduced rabbit, which consumes the grass needed by the sheep and cattle. Australia about equals the United States in area but has nearly three times as many sheep as our country and leads the world in exports of wool. The ranches or sheep stations of the interior maintain excellent breeds for producing wool —merinos and crossbred merinos—with English mutton breeds. The fleeces are carefully clipped, handled, and graded for export. Exports of lamb and mutton are important but are exceeded by those from New Zealand.

The raising of cattle is a leading industry but falls far behind that of sheep production. Most cattle are grown in the eastern section, but they are also raised in the northern regions where the weather is too warm for sheep. Dairying is increasing and is of great importance. In exports of butter and cheese, New Zealand is far ahead of Australia. The invention of artificial refrigeration has made possible the export of mutton, beef, and dairy products to distant markets. Millions of rabbit skins used for cheap furs and felt hats are exported from Australia.

Wheat is the principal grain raised in Australia, and shiploads are exported, especially from the ports of South Australia. Citrus fruit and grapes are grown principally in dry frost-free regions like the Murray River Valley. Most of these are sold in the domestic market, but exports are increasing. Apples and berries are locally of importance in Tasmania.

Australia's Future. Australia has some supplies of coal, mined chiefly in New South Wales and in Victoria; she lacks petroleum, however, and must import gasoline and fuel oil. Iron ore occurs principally in south Australia and western Australia and is smelted at Newcastle. Lead and zinc come from Broken Hill and other mining centers.

Manufacturing is increasing. Wool, metals, hides, wheat, and hardwood are among the raw materials that are processed. Nevertheless Australians import a large part of the manufactured articles they use from England, the United States, and other nations.

The continent can probably support several times its present population, with no decrease in living standards, but the large extent of desert and tropical land would seem to preclude a population density equal to that of the United States or western Europe except in the favored valleys and the southern corners of the Commonwealth.

Antarctica. Antarctica is the least known of any continent; it supports no permanent inhabitants. A vast glacier covers the land and rises to an ice plateau with an elevation of over 2 miles above the sea. There are a few exposures of bedrock, some of which contain coal beds, proof that once the climate here was mild enough for luxuriant plant growth. Only part of Antarctica has been explored and mapped, and the area of the continent is uncertain. Extensive ice floes and shelf ice prevent landings on the continent during most of the year. The Antarctic Sea is the home of many whales, and whaling is the only commercial enterprise in the area at present.

Problems

1. What geographical factors were in part responsible for the decline of the ancient Mediterranean civilizations and the rise of nations in northern Europe?
2. What nations of Europe experience some degree of geographical isolation from the rest of the continent? How has this affected their activities?
3. What is the principal urban center for each of the following plains: Danube Basin, Bohemian plain, London Basin, Po Valley, Ukraine, Ulster Basin, Wallachian plain?
4. Compare, from every possible geographical viewpoint, the peninsulas of Iberia, Italy, and Greece.
5. Locate the following mountain passes, and indicate the regions they connect: Brenner, St. Gotthard, Vardar, Pear Tree, Moravian Gate, Belfort Gap, Burgundy Gate.
6. If the Himalayas did not exist, would interior Asia be more or less habitable than it now is? Give your reasons for your answer.
7. Compare and contrast from every possible geographical viewpoint the plains of the Si (West) River, the Yangtze, and the Yellow River.
8. From the human standpoint, which of the above river plains is the most useful? Defend your answer with necessary arguments.
9. Which continent—South America, Africa, or Australia—do you regard as having the most favorable future for human occupation? Provide statements to support your conclusion.

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